PROCEEDINGS

AND

TRANSACTIONS

OF THE

LIVERPOOL BIOLOGICAL SOCIETY.

VOL. VI.

SESSION 1891—92.

LIVERPOOL:
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PROCEEDINGS

OF THE

LIVERPOOL BIOLOGICAL SOCIETY.

OFFICE-BEARERS AND COUNCIL

FOR SESSION VI., 1891—92.

President:

T. J. MOORE, A.L.S., C.M.Z.S., Lond.

Vice-Presidents:

J. DRYSDALE, M.D., F.R.M.S.

Professor W. A. HERDMAN, D.Sc., F.R.S.

Hon. Treasurer:

ISAAC C. THOMPSON, F.L.S., F.R.M.S.

Hon. Librarian:

R. HANITSCH, Ph.D.

Hon. Secretary:

JOSEPH A. CLUBB.

Council:

H. C. BEASLEY.

R. J. HARVEY GIBSON, M.A., F.L.S.

Prof. FRANCIS GOTCH, F.R.S.

W. J. HALLS.

CHARLES W. JONES.

ALFRED LEICESTER.

J. LOMAS, Assoc. N.S.S.

G. H. MORTON, F.G.S.

W. NARRAMORE, F.L.S.

J. NEWTON, M.R.C.S.

THOS. C. RYLEY.

A. O. WALKER, F.L.S.

REPORT of COUNCIL.

During the Session 1891—92 there have been eight ordinary meetings of the Society, held as heretofore at University College, and one field meeting at Hilbre Island in June, 1892.

During this session the Society has lost by death three well-known members, Mr, Thomas Higgins, F.L.S., Mr. F. Archer, B.A., and Mr. A. Norman Tate, F.I.C. Mr. Archer's place on the Council was filled up by the election of Professor Gotch.

As on former occasions the Society has been favoured with an address from a distinguished Biologist from another centre, viz., Professor G. B. Howes of the Royal College of Science, South Kensington, whose paper, on the Marsipobranch Fishes, was much appreciated.

The communications made to the Society have been representative of almost all branches of Biology, and many interesting exhibits have been submitted at the meetings.

The Library still continues to make satisfactory progress as shewn by the Librarian's Report which follows.

The Treasurer's usual statement and Balance Sheet are appended.

No alterations have been made in the laws of the Society during the past session.

The members at present on the roll are as follows:—

Honorary Members	7
Ordinary Members	67
Student Members.....	24
Total.....	98

SUMMARY of PROCEEDINGS at the MEETINGS.

The first meeting of the sixth session was held at University College on Friday, 9th October, 1891, Mr. T. J. Moore, President, in the chair.

1. The Report of the Council on the Session 1890-91 (see "Proceedings," Vol. V., p. viii.) was read and adopted.
2. The Treasurer's Balance Sheet for the Session 1890-91 (see "Proceedings," Vol. V., p. xxviii) was submitted and approved.
3. The Report of the Librarian (see "Proceedings," Vol. V., p. xxiv.) was submitted and approved.
4. The following Office-bearers and Council for the ensuing session were elected:—Vice-Presidents, J. Drysdale, M.D., F.R.M.S., Professor W. A. Herdman, F.R.S.; Treasurer, Isaac C. Thompson, F.L.S., F.R.M.S.; Librarian, R. Hanitsch, Ph.D.; Secretary, J. A. Clubb; Council, F. Archer, B.A., H. C. Beasley, R. J. Harvey Gibson, M.A., F.L.S., W. J. Halls, Charles W. Jones, Alfred Leicester, J. Lomas, Assoc. N.S.S., G. H. Morton, F.G.S., W. Narramore, F.L.S., J. Newton, M.R.C.S., Thos. C. Ryley, and A. O. Walker, F.L.S.
5. The Presidential Address, owing to the indisposition of the President, was read by Professor Herdman. It was entitled "Notes on the History of the Living Collections at Knowsley" Part II. (see "Transactions" this volume, p. 1.), and was illustrated by many specimens from the Derby Museum, stuffed specimens, skeletons, &c.

A vote of thanks to the President was proposed by Mr. Leicester, and seconded by Mr. Morton, and carried unanimously.

6. Prof. Herdman read a communication on "Ostrich Breeding" by Mr. Thomas Tillrook.

7. Prof. Herdman exhibited a pink marine micro-organism, with the following remarks:—While dredging lately in Loch Fyne I noticed through the water in a little shallow bay on the north side of the entrance to East Loch Tarbert, a number of pink patches on the sand. These could just be reached by wading from a boat at the lowest tides, and were then found to be roughly circular spots about a foot in diameter where the clean white sand was discoloured, most of the surface grains being almost exactly the tint of ordinary pink blotting paper. Under a low power of the microscope it is seen that the pink particles are ordinary clear quartz sand grains encrusted with little bright pink jelly masses generally of elongated or sausage-like forms and averaging 0·1 mm in length. Further magnification shows that each jelly mass is crowded with minute very short rods, or ellipsoids, of about 0·0015 mm in length and about half as much in breadth. This appears to be a micro-organism in the zoogloœa condition, and I do not know that any such pink marine form living on clean sand in pure sea-water has been noticed. It may possibly be one of the forms of *Beggiatoa rosea-persicina*, but it does not agree satisfactorily with any of the descriptions I have seen.

8. Mr. R. J. Harvey Gibson, M.A., F.L.S., exhibited and made a few remarks upon some Fresh-water Algæ from Lismore Lochs.

The second meeting of the Society was held at University College on Friday, 13th November, 1891, Professor Herdman, Vice-President, in the chair.

1. Mr. A. E. Ewart exhibited and briefly described some Botanical Models, recently acquired by the Botanical Department of University College.
2. Mr. G. H. Morton, F.G.S., described the structure and arrangement of some Palæozoic Sponge Spicules.
3. Mr. H. C. Beasley exhibited with remarks some insect larvæ *(Tribolium ferrugineum)* found in a cargo of rice.
4. Mr F. Archer, B.A., exhibited a collection of shells from the coast of California.
5. Other exhibits included a gigantic specimen of a puff-ball of the genus *Lycoperdon*, and a large wasp's nest built between the beams of a house at Aigburth.
6. Prof. G. B. Howes, of the Royal College of Science, South Kensington, delivered an address "In defence of the Marsipobranchs" (see "Transactions," p. 122). It was illustrated by specimens, dissections and diagrams.

   A vote of thanks was proposed to Prof. Howes by Prof. Herdman, seconded by Mr. Lomas, and carried unanimously.

The third meeting of the Society was held at University College on Friday, 11th December, 1891, Mr. T. J. Moore, President, in the chair.

1. Exhibition of Botanical Models and Tropical Plants *(Pistia, Cephalotus, Sarracenia, &c.)* by Mr. R. J. Harvey Gibson, M.A., F.L.S.
2. Note on *Sutherlandia frutescens* from South Africa by Mr. R. J. Harvey Gibson, M.A., F.L.S.

3. Mr. I. C. Thompson exhibited an illustrated manuscript work on Entomostraca by the late Dr. Baird.
4. The President intimated that a Seal had been captured by some fishermen during the previous week at Hoylake.
5. Prof. Herdman laid before the Society the Fifth Annual Report on the Puffin Island Biological Station and the L.M.B.C. Dredging Expeditions (see "Transactions," p. 10). It was illustrated by specimens, diagrams, &c.
6. The President referred in sympathetic terms to the death of Mr. Thomas Higgin, who had been a member of the Society from its commencement.

The fourth meeting of the Society was held in University College on Friday, 22nd January, 1892, Prof. Herdman, Vice-President, in the chair.

1. The congratulations of the Society were accorded to Mr. G. H. Morton, F.G.S., the Lyell Medallist of the Geological Society for the year.
2. Mr. Paden exhibited a specimen of the Müller's Top-Knot *(Rhombus punctatus)*.
3. Mr. Harvey Gibson exhibited and described an Auxanometer.
4. A Ganoid fish *(Calamoichthys calabaricus)* was exhibited, and observations made thereon by Mr. Christophers, Dr Hanitsch and Mr. Paden.
5. Dr. Leslie Roberts read a paper on *Trichophyton* (the ring-worm fungus), illustrated by diagrams. Preparations of the fungus in various media were exhibited. A discussion followed.

The fifth meeting of the Society was held at University College on Friday, 12th February, 1892, Prof. Herdman, Vice-President, in the chair.

1. The Chairman communicated the fact that a sale catalogue of the Knowsley Collection, now very rare had been presented to the Historical Society.
2. The Congratulations of the Society were accorded to Mr. T. J. Moore, President of the Society, on his election to the vacant Associateship of the Linnean Society.
3. Miss F. Phillips exhibited with remarks some of her original drawings made from living marine animals.
4. Mr. G. F. Moore exhibited a human skeleton with an apparent supernumerary vertebra and ribs.
5. Mr. G. H. Morton gave a short note on some varieties of *Purpura lapillus*, and a discussion followed.
6. Mr. R. Paden exhibited a stuffed specimen of the "Bittern" *(Botaurus stellaris)*, which had been shot in the neighbourhood.
7. Mr. Harvey Gibson exhibited and described a fungus obtained from the Physiological Laboratory, and probably new to science.
8. Prof. Herdman gave an account of the Anatomy and Histology of *Oikopleura* (see "Transactions," p. 40). Models prepared by Miss J. H. Willmer, illustrating various anatomical points, were exhibited. A discussion followed.

The sixth meeting of the Society was held at University College on Friday, 11th March, 1892, Prof. Herdman, Vice-President, in the chair.

1. Reference was made from the chair to the recent death of Mr. F. Archer, B.A., whose enthusiastic work, especially in Marine Biology was so well known.
2. Mr. I. C. Thompson gave a brief account of the arrangements made for the establishment of the Marine Biological Station at Port Erin, Isle of Man.

3. Mr. W. Garstang, M.A., read a paper on some supposed peculiarities of *Appendicularia mossi* (see "Transactions," p. 57).
4. Prof. Herdman gave an interesting account of the scientific cruise of Mr. Alfred Holt's Yacht "Argo" along the West Coast of Norway to the North Cape, illustrated by lantern slides and microscopic preparations (see "Transactions," p. 70). The various collections made by dredging from the "Argo" were on exhibition.

The seventh meeting of the Society was held at University College on Friday, 8th April, 1892, Prof. Herdman, Vice-President, in the chair.

1. A paper on the Hydroida of the Isle of Man, by Mr. G. W. Wood, F.I.C., was communicated by the Secretary (see "Transactions," p. 94).
2. Miss Phillips exhibited some original drawings, and a specimen of the cotton weed, (*Diotis marinus*).
3. A collection of shells made by Dr. Jessham from the Isle of Perim in the Red Sea was exhibited.
4. The Report on the Pycnogonida by Mr. Alf. O. Walker and Dr. Hurst was laid on the table.
5. Dr. Hanitsch exhibited a collection of sponges from the Torres Straits.
6. Prof. Herdman gave an account of the establishment of a Fisheries Laboratory on the roof of the College Buildings, in connection with the Sea-fisheries Committee of the Lancashire and Cheshire County Councils.

The eighth meeting of the sixth Session was held at University College on Friday, 13th May, 1891, Prof. Herdman, Vice-President, in the chair.

1. Miss Wood exhibited some original drawings of marine invertebrata, made for the Smithsonian Institution in America.
2. Dr. J. W. Ellis exhibited a series of specimens illustrative of the coprophagous lamellicorn Coleoptera of Bengal. The species belonged to such genera as *Ateuchus*, *Gymnoplemous*, *Copris*, *Onitis*, and *Onthophagus*, and were collected thirty years ago by Surgeon-Major Archer. They form part of the collection of Coleoptera, formed by the late Francis Archer, which by the kindness of his brother has passed into Dr. Ellis's keeping.
3. The Chairman reported on the progress made in the establishment of the Biological Station at Port Erin, and intimated that the opening ceremony was to take place at Whitsuntide.
4. The Report on the Podophthalmatous Crustacea of the District by Mr. Alf. O. Walker was laid on the table (see "Transactions," p. 96).
5. It was agreed that in accordance with the wishes of Surgeon-Colonel S. Archer, the manuscript notes on the Mollusca of the District by the late Mr. F. Archer, should be forwarded to Mr. B. Tomlin, an authority on the subject, for revision before printing (see "Transactions," p. 105).
6. The following resolution proposed by Mr. I. C. Thompson, and seconded by Mr. Harvey Gibson was carried with acclamation :—"That the hearty congratulations of this Society be given to Prof. Herdman and to Prof. Gotch upon their selection as candidates for the honour of Fellowship of the Royal Society."
7. Prof. Gotch lectured on the Electric Organs of Fishes, illustrated by specimens of *Torpedo*, *Gymnotus*,

Malapterurus, *Mormyrus* and *Raia* from the Free Public Museum and the Zoological Museum of University College, and by numerous microscopic sections and lantern slides (see "Transactions," p. 148).

The ninth and last meeting of the Society for the sixth Session took the form of an excursion to Hilbre Island on June 25th, 1892. Prof. W. A. Herdman, Vice-President, took the chair at the business meeting held subsequently, when on the motion of Mr. H. C. Beasley, seconded by Mr. Alfred Leicester, Mr. Alfred O. Walker, F.L.S., was elected President for the ensuing Session.

LAWS of the LIVERPOOL BIOLOGICAL SOCIETY.

I.—The name of the Society shall be the "Liverpool Biological Society," and its object the advancement of Biological Science.

II.—The Ordinary Meetings of the Society shall be held at University College, at Seven o'clock, during the six Winter months, on the second Friday evening in every month, or at such other place or time as the Council may appoint.

III.—The business of the Society shall be conducted by a President, two Vice-Presidents, a Treasurer, a Secretary, a Librarian, and twelve other Members, who shall form a Council; four to constitute a quorum.

IV.—The President, Vice-Presidents, Treasurer, Secretary, Librarian, and Council shall be elected annually, by ballot, in the manner hereinafter mentioned.

V.—The President shall be elected by the Council (subject to the approval of the Society) at the last Meeting of the Session, and take office at the ensuing Annual Meeting.

VI.—The mode of election of the Vice-Presidents, Treasurer, Secretary, Librarian, and Council shall be in form and manner following:—It shall be the duty of the retiring Council at their final meeting to suggest the names of Members to fill the offices of Vice-Presidents, Treasurer, Secretary, Librarian, and of four Members who were not

on the last Council to be on the Council for the ensuing session, and formally to submit to the Society, for election at the Annual Meeting, the names so suggested. The Secretary shall make out and send to each Member of the Society, with the circular convening the Annual Meeting, a printed list of the retiring Council, stating the date of the election of each Member, and the number of his attendances at the Council Meetings during the past session; and another containing the names of the Members suggested for election, by which lists, and no others, the votes shall be taken. It shall, however, be open to any Member to substitute any other names in place of those upon the lists, sufficient space being left for that purpose. Should any list when delivered to the President contain other than the proper number of names, that list and the votes thereby given shall be absolutely void. Every list must be handed in personally by the Member at the time of voting. Vacancies occurring otherwise than by regular annual retirement shall be filled by the Council.

VII.—Every Candidate for Membership shall be proposed by three or more Members, one of the proposers from personal knowledge. The nomination shall be read from the Chair at any Ordinary Meeting, and the Candidate therein recommended shall be balloted for at the succeeding Ordinary Meeting. Ten black balls shall exclude.

VIII.—When a person has been elected a Member, the Secretary shall inform him thereof, by letter, and shall at the same time forward him a copy of the Laws of the Society.

IX.—Every person so elected shall within one calendar month after the date of such election pay an Entrance Fee of Half a Guinea and an Annual Subscription of One

Guinea (except in the case of Student Members); but the Council shall have the power in exceptional cases, of extending the period for such payment. No Entrance Fee shall be paid on re-election by any Member who has paid such fee.

X.—The Subscription (except in the case of Student Members) shall be One Guinea per annum, payable in advance, on the day of the Annual Meeting in October.

XI.—Members may compound for their Annual Subscriptions by a single payment of Ten Guineas.

XII.—There shall also be a class of Student Members, paying an Entrance fee of Two Shillings and Sixpence, and a Subscription of Five Shillings per annum.

XIII.—All nominations of Student Members shall be passed by the Council previous to nomination at an Ordinary Meeting. When elected, Student Members shall be entitled to all the privileges of Ordinary Members, except that they shall not receive the publications of the Society, nor vote at the Meetings, nor serve on the Council.

XIV.—Resignation of Membership shall be signified *in writing* to the Secretary, but the Member so resigning shall be liable for the payment of his Annual Subscription, and all arrears up to the date of his resignation.

XV.—The Annual Meeting shall be held on the second Friday in October, or such other convenient day in the month as the Council may appoint, when a Report of the Council on the affairs of the Society, and a Balance Sheet, duly signed by the Auditors previously appointed by the Council, shall be read.

XVI.—Any person (not resident within ten miles of Liverpool) eminent in Biological Science, or who may have rendered valuable services to the Society, shall be eligible

as an Honorary Member; but the number of such Members shall not exceed fifteen at any one time.

XVII.—Captains of vessels and others contributing objects of interest shall be admissible as Associates for a period of three years, subject to re-election at the end of that time.

XVIII.—Such Honorary Members and Associates shall be nominated by the Council, elected by a majority at an Ordinary Meeting, and have the privilege of attending and taking part in the Meetings of the Society, but not voting.

XIX.—Should there appear cause in the opinion of the Council for the expulsion from the Society of any Member, a Special General Meeting of the Society shall be called by the Council for that purpose; and if two-thirds of those voting agree that such Member be expelled, the Chairman shall declare this decision, and the name of such Member shall be erased from the books.

XX.—Every Member shall have the privilege of introducing one visitor at each Ordinary Meeting. The same person shall not be admissible more than twice during the same session.

XXI.—Notices of all Ordinary or Special Meetings shall be issued to each Member by the Secretary, at least three days before such Meeting.

XXII.—The President, Council, or any ten Members can convene a Special General Meeting, to be called within fourteen days, by giving notice in writing to the Secretary, and Stating the object of the desired Meeting. The Circular convening the Meeting must state the purpose thereof.

XXIII.—Votes in all elections shall be taken by ballot, and in other cases by show of hands, unless a ballot be first demanded.

XXIV.—No alteration shall be made in these Laws, except at an Annual Meeting, or a Special Meeting called for that purpose; and notice in writing of any proposed alteration shall be given to the council, and read at the Ordinary Meeting, at least a month previous to the meeting at which such alteration is to be considered, and the proposed alteration shall also be printed in the circular convening such meeting: but the council shall have the power of enacting such Bye-laws as may be deemed necessary, which Bye-laws shall have the full power of Laws until the ensuing Annual Meeting, or a Special Meeting convened for their consideration.

BYE-LAW.

Student Members of the Society may be admitted as Ordinary Members without re-election upon payment of the Ordinary Member's Subscription; and they shall be exempt from the Ordinary Member's entrance fee.

LIST of MEMBERS of the LIVERPOOL BIOLOGICAL SOCIETY.

SESSION 1891-92.

A. Ordinary Members.

(Life Members are marked with an asterisk.)

ELECTED.

1890 Archer. F., B.A., 21, Mulgrave-street
1890 Assheton, R., M.A., Owens College, Manchester
1888 Atkin, Hope T., Egerton House, Egerton Park, Rock Ferry
1886 Banks, Prof. W. Mitchell, M.D., F.R.C.S., 28, Rodney-street
1890 Batters, E. A. L., B.A., LL.B., F.L.S., The Laurels, Wormley, Herts
1886 Barron, Prof. Alexander, M.B., M.R.C.S., 31, Rodney-street
1888 Beasley, Henry C., Prince Albert-road, Wavertree
1892 Biddle, Leonard F., 21, Canning-street
1889 Brown, Prof. J. Campbell, 27, Abercromby-square
1887 Caine, Nathaniel, 10, Orange-court, Castle-street
1886 Caton, R., M.D., F.R.C.P., Lea Hall, Gateacre
1886 Clubb, J. A., Secretary, University College, Liverpool
1890 Davies, D., 55, Berkley-street
1890 Dawson, R. A., Glengarry, Lytham
1886 Dillcock, T., 8, Church-street, Egremont
1891 Dismore, Miss, 65, Shrewsbury-road, Oxton
1886 Drysdale, John, M.D., Vice-president, 36a, Rodney-street

1889 Dwerryhouse, A. R., Church-end Farm, Hale
1886 Ellis, J. W., M.B. (Vic.), F.E.S., 18, Rodney-st.
1890 Ewart, A. J., University College, Liverpool
1891 Garstang, W., M.A., Marine Biological Laboratory, Plymouth
1886 Glynn, Prof. T. R., M.D., F.R.C.P., 62, Rodney-street
1886 Gibson, R. J. Harvey, M.A., F.L.S., University College
1891 Gotch, Prof. F., F.R.S., University College
1886 Halls, W. J., 35, Lord-street
1887 Hanitsch, R., Ph.D., LIBRARIAN, University College, Liverpool
1887 Healey, George F., Oakfield, Gateacre
1886 Herdman, Prof. W. A., D.Sc., F.R.S., VICE-PRESIDENT, University College
1891 Hicks, J. Sibley, M.D., 2, Erskine-street
1886 Higgin, T., F.L.S., Ethersall, Mossley Hill
1888 Hurst, C. H., Ph.D., Owens College, Manchester
1886 Jones, Charles W., Field House, Prince Alfred-road, Wavertree
1886 Leicester, Alfred, Priory Gardens, Birkdale
1886 Lomas, J., Assoc.N.S.S., Salen, Awery Grove, Birkenhead
1890 Lowndes, W., 173, Lodge-lane
1888 Melly, W. R., 90, Chatham-street
1886 McMillan, William S., F.L.S., Brook-road, Maghull
1886 McClelland, Joseph, M.D., 7, Sefton-drive, Sefton Park
1886 Moore, Thomas J., C.M.Z.S., A.L.S., PRESIDENT, Free Museum
1886 Moore, G. F., 15, Kremlin-drive, Tuebrook
1886 Morton, G. H., F.G.S., 209, Edge-lane, E.
1888 Newton, John, M.R.C.S., 44, Rodney-street

1887 Narramore, W., F.L.S., 5, Geneva-road, Elm Park
1891 Phillips, Miss F., 3, Green-lawn, Rock Ferry
1888 Phillips, Prof. Reg. W., M.A., University College, Bangor
1886 *Poole, Sir James, J.P., Abercromby Square
1890 Rathbone, Miss May, Backwood, Neston
1890 Roberts, Leslie, M.B., 31, Rodney-street
1887 Robertson, Helenus R., Normanton House, Normanton-avenue
1887 Rowlands, W. Ellison, 28, Green-lane, Stoneycroft
1887 Ryley, Thomas C., 10, Waverley-road
1881 Sharp, W. E., The Woodlands, Ledsham, Chester
1886 Smith, Andrew T., Jun., 13, Bentley-road, Prince's Park
1889 Stewart, W. J., B.A., 26, Lord-street
1886 Tate, A. Norman, F.I.C., 9, Hackins-hey
1886 Thompson, Isaac C., F.L.S., F.R.M.S., TREASURER, Woodstock, Waverley-road
1889 Thornely, Miss L. R., Baycliff, Woolton Hill
1889 Thurston, Edgar, Gov. Central Museum, Egmont, Madras, India
1888 Toll, J. M., 340, Walton Breck-road
1886 Vicars, John, 8, St. Albans-square, Bootle
1886 Walker, Alfred O., J.P., F.L.S., Colwyn Bay
1889 White, P. H., M.B., University College, Bangor
1889 Williams, Miss Leonora, 55, Rocky-lane
1891 Wiglesworth, J., M.D., County Asylum, Rainhill
1891 Wood, G. W., F.I.C., Riggindale-road, Streatham, London
1892 Weiss, Prof., Owens College, Manchester
1892 Young, T. F., M.D., 12, Merton-road, Bootle

B. Student Members.

Anderson, E. L., 31, Fitzclarence-street, Everton
Armstrong Miss A., 26, Trinity-road, Bootle
Armstrong, H., Stainsland, Spital, Cheshire
Baylis, W. J., 56, Vine-street
Buckley, Miss L., B.Sc., University College, Liverpool
Christophers, S. R., 10, Lily-road, Fairfield
Cutmore, J. W., 49, Hardman-street
Dickinson, T., 3, Clark-street, Prince's Park
Dumergue, A. F., 7, Montpellier-terrace, Up. Parliament-st.
Earnshaw, W. H., Leavy Greave, Rudgrave-pl., Egremont
Gould, Joseph, Littledale-road, Egremont
Hannah, J. H. W., 4, Adderley-street, Edge-lane
Harding, Miss M., Kremlin-drive, West Derby
Henderson, W. S., 2, Holly-road, Fairfield
Laslett, E. E., University-road, Bootle
Paden, R., Free Museum
Palethorpe, Miss F., 14, Sandon-street
Ross, S. J., 18, Lawrence-road, Wavertree
Simpson, A. Hope, Annandale, Sefton Park
Stubbs, M. C., Wavertree Rectory
Waterhouse, W. J., 185, Lord-street, Southport
Whitwam, L. S., 8, Hawarden-avenue, Wavertree
Willmer, Miss J. H., Westbourne-road, Birkenhead
Williams, Henry, Jun., 57, Balliol-road, Bootle

C. Honorary Members.

H.S.H. Albert I., Prince of Monaco, 25, Faubourg St. Honore, Paris
Bornet, Dr. Edouard, Quai de la Tournelle 27, Paris
Claus, Prof. Carl, University, Vienna
Fritsch, Prof. Anton, Museum, Prague, Bohemia
Giard, Prof. Alfred, Sorbonne, Paris
Haeckel, Prof. Dr., University, Jena
Marshall, Prof. A. Milnes, D.Sc., F.R.S., Manchester

REPORT of the LIBRARIAN.

Our Society has arranged an exchange of publications with three additional Societies since the last Report, making in all sixty-one Societies. In July, 1891, the Library contained 1194 volumes and pamphlets. It now numbers 1574, an increase of 380 in the year. The following list gives the titles of the exchanges and donations received during the session :—

1. Archives Néerlandaises des Sciences exactes et naturelles. Tome xxv., Nos. 2—4, Tome xxvi., No. 1.
2. The Australian Museum, Sydney. Records : Vol. i., Nos., 6, 7, 8, 10.—Vol. ii., No. 1. Report of the Trustees for 1890. Catalogue No. 15 Marine Shells of Australia and Tasmania. Part 1.
3. Berichte der naturforschenden Gesellschaft zu Freiburg i, B. Band v, Nos. 1 and 2.
4. Berichte über die Senckenbergische naturforschende Gesellschaft n Frankfurt a. M. 1891.
5. Berichte der Königl. Sächs. Gesellschaft der Wissenschaften zu Leipzig. 1891, ii—v ; 1892, i.
6. Société Imperiale des Naturalistes de Moscou. Bulletin 1891, Nos. 1—4. 1892, No. 1.
7. Bulletin of the Museum of Comparative Zoology, at Harvard College. Vol. xvi., No. 10, xxi., 5 ; xxii., Nos. 1—3 ; xxiii., 1—2. Annual Report 1890—91.
8. United States Commission of Fish and Fisheries. Report of the Commissioner for 1887.
9. Fishery Board for Scotland. Ninth Annual Report.
10. Journal of the Marine Biological Association. N.S. Vol. ii., Nos. 2 and 3.
11. Math. u. naturw. Mittheilungen aus. d. Sitzungsber. d. königl. preuss. Akademie der Wissenschaften zu Berlin. Mai, 1891—Sitzungsberichte 1891, Nos. xxv—liii.
12. Mémoires de la Société Zoologique de France. Tome iii., No. 5 ; Tome iv., Nos. 1—4. Bulletin, Tome xvi., Nos. 2—8.

13. Mémoires de la Société Physique et d' Histoire Naturelle de Genève. Vol. supplémentaire. Centenaire de la fondation.
14. Proceedings and Transactions of the Natural History Society of Glasgow. N.S. Vol. iii., part 2, (1889—90).
15. Proceedings of the Academy of Natural Science of Philadelphia. 1891, parts 2 and 3 ; 1892, part 1.
16. Transactions of the Canadian Institute, Toronto, Vol. ii., parts 1 and 2. Annual Archaeological Report 1891. An appeal to the Canadian Institute on the Rectification of Parliament.
17. Proceedings of the Royal Physical Society Edinburgh. Session 1890-91.
18. Scientific Transactions of the Royal Dublin Society. Vol. iv., Nos. 6—8. Proceedings Vol. vi., No. 10 ; Vol. vii., Nos. 1 and 2.
19. Transactions and Annual Report of the Manchester Microscopical Society. 1891.
20. Verhandlungen der k.k. zoologisch-botanischen Gesellschaft in Wien. 1891, Nos. 1—4.
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52. The Lysianassides of the "British Sessile-eyed Crustacea," Bate and Westwood. By Alfred O. Walker. Presented by the author.
53. Voärufiger Bericht über die Fauna des Unter—Pocernitzer und Gatterschlager Teiches. By A. Fritsch u. V. Vávra. Presented by the authors.
54. I. Distomi dei pesci marini e d'acqua dolce. By Michele Stossich. Il genere *Dispharagus*. By the same. Elminti Veneti Raccolti. By

the same. I Distomi degli Uccelli. By the same. I Distomi degli Anfibi. By the same. Presented by the author.

55. The Coleopterous Fauna of the Liverpool District. By John W. Ellis, M.B., F.E.S. Presented by the author.

56. The Lepidopterous Fauna of Lancashire and Cheshire. By John W. Ellis, M.B., F.E.S. Presented by the author.

57. Sur quelques plantes vivant dans le test calcaire des Mollusques. Tableau synoptique des Nostochacées filamenteuses hétérocystées. Par Mon. Ed. Bornet et Ch. Flahault. And various other papers. Presented by M. Ed. Bornet.

58. Note sur quelques Ectocarpus. By M. Ed. Bornet. Note sur *l'Ostracoblabe implexa*, Born. et. Flah. By the same. Algues du département de la Haute—Vienne contenues dans l'herbier d' Edouard Lamy de la Chapelle. By the same. Presented by the author.

59. Il Genere *Heterakis*, Dujardin. By Michele Stossich. Il Genere *Physaloptera*, Rudolphi. By the same. Presented by the author.

60. Theories of Coral Reefs and Atolls. By Sydney J. Hickson. Presented by Prof. Herdman.

61. Notes on Polyzoa found at Cleethorpes. By George Roberts Vine. Presented by Mr J. Lomas, Assoc. N.S.S.

THE LIVERPOOL BIOLOGICAL SOCIETY,

Dr. IN ACCOUNT WITH ISAAC C. THOMPSON, HON. TREASURER **Cr.**

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HON. TREASURER.

LIVERPOOL, *July* 1*st*, 1892.

Audited and found correct,
ALFRED LEICESTER.

TRANSACTIONS

OF THE

LIVERPOOL BIOLOGICAL SOCIETY.

OPENING ADDRESS:

NOTES ON THE

HISTORY OF THE LIVING COLLECTIONS AT KNOWSLEY.

By T. J. Moore, Corr. M.Z.S. Lond., President.

Part II.*

The object most earnestly pursued by the Thirteenth Earl of Derby was to introduce and, if possible, naturalize such Birds and Beasts as would be ornamental or useful. As a consequence Deer and Antelopes, Zebras and Alpacas and Brahmin Cattle, among Quadrupeds, received his principal care: Game Birds and Waterfowl, Cranes and the Ostrich Tribe among Birds.

The Wapiti Deer of North America, one of the largest living species, bred freely at Knowsley, and the antlers attained a large size. The Bara Singha Deer, so called from the twelve points in the pair of horns of the fully adult specimens are well known to Indian sportsmen, and were fairly represented in the collection. The Barbary Deer, the only Deer found in Africa, was represented at the sale by half a dozen specimens, two-thirds of which were adult, and *all* Knowsley bred. Of the Hog Deer of India, a small but most robust and vigorous species, seven home-bred specimens were included. Though not standing higher than a man's knee, their strength and activity were so great that none but their keeper ventured among them in their paddock, and that with caution

* For Part I. see Trans., vol. V., p. 1.

when their horns were fully developed. The same was the case with the Sambur, a larger and heavier species, represented by three Knowsley bred individuals; indeed the most redoubtable beasts at Knowsley were a Sambur Stag, a Wild Ass and a male Guanaco, any one of which was shunned as being quite capable of killing a man, and not at all unwilling to do so. Happily no fatality occurred, but great vigilance was exercised to prevent it. The Leucoryx with long curved horns nearly probed his keeper's ribs. The Wild Ass just missed seizing *his* keeper with his teeth, his nostrils distended, like quart pots, with rage; the Guanaco dragged continually a long chain to restrain *his* activity; while on one summer's night the Elk escaped from his plantation and caused a poor little belated coachman to spend the night in a tree alarmed by the ominous grunting of the Elk rapidly advancing in the dark.

A grand field day came off every now and then, when the Zebras and the Wild Ass needed their corns cutting, or in other words required their hoofs to be pared, the soft verdure of their paddocks not sufficing to keep them down. Then all hands were mustered; the blacksmith, tall and gaunt, spare of words and strong of limb, well provided with long and strong leather straps with running buckles, together with the superintendent, would marshall the forces say in a Zebras den (such as may be seen in the Zebra house of the Zoological Gardens in the Regent's Park), warily seeking to catch a Zebra's hoof in the running noose, the Zebra as warily doing his best to keep it out and give any or all concerned "one for themselves," but ultimately being caught and finally cast and held fast by a strap to each foot while the tormentors held down his head and sat on his neck and flanks, making a cruel mockery of his gallant resistance. Then the

blacksmith, sweating at every pore, would make the best of his time and opportunity to pare and trim each long grown hoof to more desirable proportions, and when all was done and the straps to be cast off, looking out every man for himself and—all for squalls. These were lively times and all was well that ended well.

On one occasion the Sambur Deer aforenamed, vicious beyond bearing, was brought to reason by a cheese-paring of this kind and then left without straw in his paddock, very neatly paved with *soft sandstone sets*, which speedily wore down his hoofs (always much thinner than any Zebra's) and so took the bounce and viciousness out of him. The Wild Ass however remained the most dreaded and dangerous beast of all; but he succumbed at last to one stronger than he; for he was found dead in his yard one winter's morning after a severe frost with his hair all turned so much the wrong way that all the efforts of the stuffers were unavailing to get it smooth again, even for the show cases of the British Museum.

Occasionally a field day of another kind came off at Knowsley: namely, the washing day of the Alpacas and Llamas. About 1842 or 43 Alpacas excited a great deal of interest. Pamphlets were published on their naturalization, and a Liverpool firm took an active part in the endeavour to import them. Mr. Dawson and Mr. Edwards of Shaw Street were earnest in the matter, and evidence of the same still exists I believe at the Royal Institution in the shape of oil colour drawings of some of these animals. They were supposed to be hardy creatures and suitable for acclimatation in Scotland and elsewhere. Lord Derby eagerly tried his hand at Knowsley. A hundred adults were shipped for Liverpool, and some fifty young ones were born during the voyage from Peru. The treatment on board ship was, I believe, not always

judicious; they were abstemious drinkers, and more water was thrust upon them than was requisite. A large number of deaths took place, and cutaneous disease or scab spread rapidly among them. Those living at Knowsley at the time of my arrival were suffering from it, and it extended to the Llamas. They were closely clipped and shorn of their wool: and anointed and drenched with vile smelling farrier's compounds, and rubbed and washed and abundantly lathered with soft soap in warm water in big tubs and vats in the well stored brew-house at Knowsley. At this treatment, offensive alike to the eyes, nostrils and ears, the Llamas, and especially Guanacoes, rebelled vigorously, violently regurgitating their champagne bottle dozes of physic, to the disgust of all concerned.

The treatment, however, which was prescribed I believe by some astute veterinary surgeon in Yorkshire, was not without beneficial effect. I don't call to mind that any of the creatures died from it, on the contrary, persistent treatment in time cured or greatly relieved all of them; but they were "field days" to be remembered, and remembered vividly as I do to this day, but I fear only one other eye-witness is now living to do so.

The Alpacas were in some instances left unshorn for a couple of seasons, when their fleece became very lengthy, and the Alpacas when clipped resembled nothing so much as so many hares mounted on stilts, *not* from their mode of progression, but from the length of their legs and the slenderness of their body. At the sale Mr. Titus Salt of Saltaire then rising into fame, bought one half of them at prices of £25 to £30 each; Prince Demidoff for his collection at Florence, and the Director of the Zoological Gardens at Antwerp, took two lots at similar prices. In all 12 specimens bred at Knowsley, 6 males and 6 females

were then disposed of as well as three Vicunas, one Guanaco and five Llamas. Two Vicunas had previously met with their death from fighting, one being killed outright by his antagonist, and the other "to save his life."

Among the Cattle living at Knowsley, were numerous examples of the Humped Indian Cattle of at least 4 different races, the largest being the white race generally called Brahmin, others Zebus, as the straight horned Zebu, and the Ghu, and the Wentworth Zebu. Of these 4 kinds there were 28 specimens, 25 having been Knowsley bred. The finest were the largest, mostly pure white shaded with grey, with heavy pendulous hump and sloping haunches. These gave rich milk and crossed readily with ordinary short horned Cattle, came early to maturity, yielded fine and tender beef, in which the fat was delicately streaked in the lean. Several of these sent to market were in good demand, and perhaps might have become more thoroughly established if more persistent efforts had been maintained. Sir John Orde in Scotland shared Lord Derby's zeal in trying to maintain the breed which was kept up for several years and was one of the successes of Knowsley.

The straight horned Zebu had longer and more widely spread horns. These beasts were of a rich brown colour and were very picturesque as indeed they all were, but were little seen even among the few visitors who were admitted, as each kind was kept isolated in separate paddocks, mostly walled in.

Beside the Humped Cattle there were one or two examples of West African Cattle, the *Bos Dante* and another. Two hybrid Yaks from Central Asia, one a Cow with boldly curving horns, a long fringe of hair hanging down from the flanks, and a fine large bushy flowing tail, so well known in the East as produced by Yaks and used

for military display. Finally there was an adult bull Bison who escaped more that once from his paddock in search of Bovine Society, and on one occasion when hurdled in by the margin of the big lake or dam in Knowsley Park, boldly swam across to the cattle on the other side some half mile distant.

One other Bovine I must mention, the *Anoa depressicornis*, of the Celebes, very rare, and the smallest Buffalo known. This is now in the Liverpool Museum. On one occasion, shut up together in a small shed, he and I had a trial of strength. I did my best and got safely away, but I don't think he did his worst: for he was very short and very strong; and his horns short and sharp, and he was merciful, and here I am. A second species closely allied to this has lately been made known from the neighbourhood of New Guinea.

Several races of Goats and Sheep were also bred at Knowsley including nearly a score of Cashmere Goats with long white silky hair (examples presented by the Queen) and half a score of Andalusian Sheep: some Dwarf Merinos, and a small flock of Demerara Sheep remarkable for their scraggy build and short hair instead of wool. But the beast I remember most was a short-legged ram with long spiral horns, who entertained views of his own as to my right of way across his bit of pasture ground. At first he showed a retiring disposition, and backed and backed some distance but suddenly made up for it by a rapid rush to the front, his horns catching me below the knees and bringing me most suddenly to grief. I ought to have known better and shown more tactical skill, for I once saw the great big burly blacksmith six feet high three times brought to his knees by an insignificant mite of a ram from whom he was trying, but in vain, to escape amongst a series of Pheasant cases with narrow lanes

between them. But don't let me mislead any of my hearers: the tactics in a contest with a ram are not suitable against a goat; of which I had had evidence some few years previously in the burial ground at the back of the College of Surgeons in London when on an errand to Professor Owen. There two billy-goats were fighting among the tombstones, and their way of settling differences was to rise to their full height on their hind legs, face to face, and to fall with all the force they could muster, front to front, and horns to horns, with fearfully resounding blows.

In the journal which I kept at Knowsley from 1843 onwards, and in which all the births, deaths and other notable events in regard to the collection were entered day by day I find many records bearing upon the extraordinary mishaps which befell some of the animals, the difficulties that had to be met and the precautions taken—especially in the rearing of the young animals. Here is an entry:—"March 19th, 1844. A male Alpaca born. It is a fine strong little animal, and for some time after birth was going on very well. Mr. Thompson (the superintendent) went to it again in an hour or two and then found it all but dead with cold and weakness. He then shifted it from the Wapiti paddocks to the old aviary where he fitted up a snug warm place for it. After a good deal of nursing it came round a bit and soon gathered strength. It is like the mother all over of a black colour." It is gratifying to read that ten days later, "March 29th. The young Alpaca is in such good health and is so strong that it is able to roam about with its dam outside the aviary. It enjoys its liberty and is very lively and playful."

Here is another entry of the birth of an Alpaca just a month later:—"April 29th, 1844. A male Alpaca born—black all over, but the mother is quite white except a

black patch the size of a saddle. This young one is larger and stronger than the one born last. April 30th. The Alpaca born yesterday is so stong as to be turned loose with its dam to roam about the grounds."

There are several records of female kangaroos dying while they had young ones in the marsupial pouch. In at least one case the attempt was made to bring up the young creature by hand. However it only lived for about a fortnight, during which time it sucked from a bottle. The following observation is interesting:—"October 16th, 1844. John Barron while cleaning his kangaroo den this morning saw one of the Jerboa Kangaroos (*Bettongia penicillata*, Gray) give birth to a young one. He distinctly saw her drop it on the boards of the den, and immediately take it up with her mouth and forefeet and put it in the pouch. It was very small, not bigger than a new born mouse, and was of a blood-red colour: it kicked about very much." This by the way is the species of kangaroo which carries about wisps of straw held in a loop of the tail when making its nest. A stuffed specimen in the Liverpool Museum shows this habit.

Many of the entries in the journal give information as to the dates and periods of breeding and development of the animals, and as to interesting crosses between different species. Here is an instance:—"April 8th, 1844. The Summer Duck paired with a female Mandarin Duck. These are two very distinct forms belonging however to the same genus. They are widely separated in their geographical range, the Summer Duck being from North America and the Mandarin from China. Here is another interesting case in connection with the breeding of birds:—The black Swans brought from Australia not only bred freely at Knowsley, but bred twice in the year. They evidently had become subject

to the influences of the northern spring of their new home without giving up the ancestral habit of breeding six months later in the spring time of Australia.

The celebrated American naturalist Audubon sent some Passenger Pigeons to Lord Derby, and they flourished so well at Knowsley that after a few years they had increased to such an extent as to be a nuisance, and eventually the doors of their aviary were opened and as many as chose were allowed to fly away. It is curious that so far as is known none of these were afterwards shot and recorded as wild birds.

The first mud-fishes (*Protopterus*), from the Gambia in West Africa, which reached this country were brought by Lord Derby's collector, Mr. Whitfield, in 1843. They were placed in the warm tanks in the plant houses, were successfully melted out of their balls of hardened mud and lived there for some time. Some of these were in all probability sent to Professor Owen and formed the basis of his well known memoir.

I am unfortunately prevented by the state of my health from adding anything further at present to these somewhat disjointed records of this notable Lancashire collection; but the manuscript journals kept by me of the living specimens at Knowsley form a mine of interesting material from which I hope on some future occasion to quarry a further instalment of "Notes" to lay before the Liverpool Biological Society.

FIFTH ANNUAL REPORT of the LIVERPOOL MARINE BIOLOGICAL STATION now on PUFFIN ISLAND.

By W. A. Herdman, D.Sc., F.L.S., F.R.S.E.,

DERBY PROFESSOR OF NATURAL HISTORY IN UNIVERSITY COLLEGE, LIVERPOOL; CHAIRMAN OF THE LIVERPOOL MARINE BIOLOGY COMMITTEE, AND DIRECTOR OF THE PUFFIN ISLAND STATION.

[Read 11th December, 1891.]

The Year.

The past year has been a most unfortunate one for marine biological work on account of the storms during the summer and autumn which interfered with our usual dredging expeditions in Liverpool Bay, and did great damage to the boats at Puffin Island. Still work has been carried on continuously at Puffin Island and in other parts of the district, and as a result not a few additions to knowledge, and advances along lines of investigation previously started, claim record in this annual report.

The Biological Station was not closed during last winter, and will be kept open during the present winter also. The keeper, Thomas Jarrett, and his wife are still in charge. At the end of autumn (October 31st, 1890) the old sailing boat, "Bonnie Doon," which had for some time been leaking badly and required frequent patching and caulking, was taken up to Cadnant (Menai Straits) and beached for the winter. A thorough examination of her in the spring showed that she was really past work. Some of her planks were so rotten that they would not bear further caulking, when a leak was stopped in one place it broke out in another, and the boat did not seem worth

the very extensive repairs which would be necessary in order to render her safe in the strong winds and heavy seas which come upon us with very short warning in the neighbourhood of Puffin Island. So the executive of the committee after full consideration reluctantly decided that the "Bonnie Doon" must be condemned and sold for what she would bring.

A new sailing boat to take her place at the island was now necessary, and a timely donation towards that purpose from Mrs. C. W. Jones encouraged the Treasurer to provide the amount required for the purchase of the "Morning Star," a second-hand, but almost new, 4 ton cutter, 21 ft. in length, which was in first rate condition and bore an excellent character at Beaumaris. She has been in constant use during the summer and autumn and has proved perfectly satisfactory.

Unfortunately during the severe gales which commenced on October 13th and continued for some time, the "Morning Star," like so many other small yachts in the neighbourhood, was sunk at her moorings, and had to be left at the bottom until the gales were over and boats and men could be got down from Bangor to raise her. After several attempts she was got up on November 24th, brought in to low water mark, bailed out, floated, and afterwards taken up to Beaumaris where she has been hauled up for the remainder of the winter. Fortunately her hull has received no damage, but several of her spars are broken or lost and the sails and rigging are destroyed and will have to be replaced in spring. To finish the record of the disasters to our boats, the old black rowing boat "Ascidian" was smashed to pieces on the beach during one of the storms; and the small blue punt was, on another occasion, sunk between tide marks, but was afterwards recovered. She has

suffered no damage to speak of, and is still in fairly serviceable condition, though showing signs of wear.

Station Record.

The Journal at the Laboratory records that the following naturalists have been working at the Biological Station for longer or shorter periods during the present summer:

DATE. 1891.	NAME.	WORK.
February.	I. C. Thompson, F.L.S., Liverpool	Copepoda.
—	Alfred Leicester, Southport	Land Mollusca.
—	W. A. Herdman, Univ. Coll., Liverpool	Nudibranchs, &c.
April.	Dr. R. Hanitsch, Univ. Coll., Liverpool	Sponges.
—	I. C. Thompson	Copepoda.
—	W. A. Herdman	Nudibranchs.
June.	W. Thornely	Zoophytes and
—	F. V. Milward	Polyzoa.
July.	Dr. G. S. Brady, F.R.S.	Copepoda.
—	I. C. Thompson	Copepoda.
—	R. J. H. Gibson, Univ. Coll., Liverpool	Algæ.
—	Rev. T. Shankland, Univ. Coll., Bangor	Land Mollusca.
August.	Miss A. E. Warham, B.Sc., U.C.L'pool.	Ascidians.
—	Miss L. Buckley, B.Sc., U.C.L'pool.	General.
—	Alfred Leicester, Southport	Land Mollusca.
—	Miss J. Leicester	,,
—	J. Coventry, Liverpool	General.
—	Rev. T. Shankland	Land Mollusca.
October.	I. C. Thompson	Copepoda.
—	W. A. Herdman	Nudibranchs, &c.

This list contains rather fewer entries than the corresponding ones for the last two years, but that may probably be accounted for by the miserable weather during the greater part of the season. Several parties which were organised to visit the Station had to be broken up, and on one occasion several of our local biologists got as far as Beaumaris on their way to Puffin Island in very bad weather, and after waiting there for a few days had to return.

It is experiences such as these, during a summer like the one we have just encountered, which unpleasantly emphasize the inconvenience of having the biological station at a somewhat inaccessible spot; and which are causing the Committee to consider the advisability, now that we have had five years work at Puffin Island, of moving the centre of operations to some suitable spot nearer home. Although a marine fauna seems practically inexhaustible, still we have certainly now found and recorded the great majority of the animals and plants of the Menai Straits, and have investigated to some extent the more characteristic and interesting forms of life, and some of the problems they present to us for solution. So it might well be found more profitable to break ground in some new part of our area, and if a suitable local habitation could be obtained somewhere in the neighbourhood of Hoylake, West Kirby, or Hilbre, although the fauna would not be so rich and varied as at Puffin, still the proximity to Liverpool would greatly facilitate work. Then again, with our biological station near a fishing centre like Hoylake, we would also be able to carry on investigations with a practical bearing which might be of importance to the fishermen, and so help our friends on the Sea Fisheries Committee of the County Council in their most necessary and valuable work for the benefit of the local fisheries. Several of the lines of investigation started by our L.M.B. Committee during the last few years—such as the distribution and composition of the surface life of the sea and its relation to the food of fishes, statistics in regard to the life-history of shrimps, and habits, growth, &c., of young mussels—have opened up avenues leading to practical results, and which ought to be pursued further; while many other problems and lines of inquiry of equal biological interest and economic importance still await investigation.

On the other hand it is possible that all such purely local work might be adequately undertaken in connection with the College Laboratories, and that the L.M.B.C. Station should be regarded as a means of investigating more outlying areas; and therefore several of the Committee are strongly of opinion that if we leave Puffin Island the station should be established at Port Erin, near the south end of the Isle of Man, for a few years, in order that the rich marine fauna of that neighbourhood may be more fully investigated.

Fig. 1.—Map of the L.M.B.C. District.

Publications.

It is proposed to issue the third volume of reports on the Fauna and Flora of Liverpool Bay during the coming season. Most of the sheets and plates for it have been printed off and stored, but as it is desired to include also those papers on the marine biology of the district which

will be laid before the Biological Society during the present session, and especially the revised reports upon the Copepoda (by Mr. Thompson), the Mollusca (by Mr. Archer), and the Pycnogonida (by Dr. Hurst and Mr. Walker), the volume will probably not be in the hands of the public until early summer.

The various L.M.B.C. papers which were announced in last year's Report as being nearly ready for publication were communicated in due course to the Biological Society and printed in the fifth volume of Transactions. The two most important of these are:—an extensive report by Mr. Harvey Gibson on the Marine Algæ, including records of 256 species of which 66 are additions to our list; and a report on the Polychætous Annelids, by Mr. J. Hornell, in which 88 species (one new to science) and two new varieties are given, three of the species being new to British waters and 39 additions to our local fauna. Mr. Moore's long promised report upon the Fishes is not yet ready. This is the more to be regretted as in view of the ever increasing attention which is being directed towards fishes, the formation of a Fisheries Committee of the County Council, the establishment of a Sea Fisheries District in our neighbourhood and the appointment of a superintendent (Mr. R. A. Dawson), with a steamer at his service and a staff of assistants, it is most desirable that we should publish a report upon the local fishes without further delay. It is hoped that Mr. Moore's improved health will permit him now to make more rapid progress with the work.

Dredging Expeditions.

For the first time in the history of these annual reports we have no "Hyæna" expedition to record. The Salvage Association, with their usual kindness, permitted us to

organize an expedition during Whit-week, but most unfortunately at the last moment when our party was assembled ready to embark for a 4 or 5 days cruise it was found to be so rough outside the river, and the telegraphic reports from Holyhead were so bad, that the captain and the officials of the Salvage Association reluctantly decided that it was not fit for the "Hyæna" to go, so the expedition was postponed for a few weeks. The decision, although disappointing at the moment, was a wise one, as it blew hard for the next three days, and even if the "Hyæna" had succeeded in reaching the north coast of Anglesey, our proposed destination, it was clear from the weather reports that we could have done no work there. A few of our party from other towns, who were to join us at Beaumaris, unfortunately did not hear of the change of plan in time and reached the Menai Straits next day by train, and spent a day or two there dredging in sheltered waters.

A second time, a few weeks later, the party was organized and all arrangements made, when a couple of days before the proposed start a disastrous collision occurred in the Mersey, a steamer was sunk, and the "Hyæna" was consequently called off to her ordinary salvage duties. The Salvage Association most kindly offered to let us have the boat later in the summer, but we were unable to take advantage of it then, and must look forward to better luck and less boisterous weather next spring.

Early in June the Sea Fisheries Committee, through their superintendent, Mr. R. A. Dawson, invited us along with some of the Southport Biologists to organize a single day dredging trip in their new Fisheries steamer "The Mavis." On this occasion (June 20th) we had beautiful weather, and did a good deal of dredging and tow-netting in the neighbourhood of Southport. The party consisted

of Mr. Fell, Mr. Muspratt, Mr. Ascroft, and Mr. Dawson of the Fisheries Committee, Dr. Chaster and several others of the Southport Natural Science Society, and Mr. Thompson, Mr. Leicester, Mr. Comber, Mr. W. J. Stewart, the Mayor of Bootle, and others of our own Committee. Although many specimens were obtained on this occasion none, so far as yet determined, were specially noteworthy or new to our records, except some fine typical specimens of the Foraminifer *Vaginulina linearis* obtained from 20 fms., about 23 miles out from Southport. Later in the summer a few of the Southport biologists went out again for a day's dredging in the "Mavis." They report having found good ground and got good hauls (Ascidians, &c.). Unfortunately our Committee were not able to take part in that expedition, and the specimens were not preserved nor recorded.

On September 26th we chartered the tug "Spindrift" for the day, and a considerable party left the Landing Stage in the morning, hoping to have some dredging in that central area, half-way to the Isle of Man, which seems so difficult to reach on our expeditions. With our usual luck we found on getting out of the river that there was a heavy sea, and although we persevered for some hours it was getting worse all the time, and so about one o'clock we turned back and had some hauls of the trawl in the afternoon in the Rock Channel where we got Starfishes, Zoophytes, Polyzoa, and other common things, none of them new to the locality.

Surface Fauna.

Mr. Thompson, who has been receiving and examining the tow-nettings taken by the keeper at Puffin Island throughout the year and also those collected on the few expeditions, says that although valuable for statistical

purposes there is comparatively little that is specially worthy of note. January (1891) was remarkable for the enormous profusion of *Sagitta* in all the tow-nettings from the neighbourhood of Puffin Island. From later in the spring on to July the gatherings from the same region were characterised by the abundance of Diatoms and a slimy *Conferva*.

In a ten-fathom dredging taken by Mr. A. O. Walker off the Little Orme, near Colwyn Bay, on May 6th, one species of Copepod occurred which is new to the district, viz., *Thalestris peltata*, Boeck. It has apparently only once been taken before in British Seas, as Brady says in regard to it "One specimen only was found in dredged material from a depth of 40 fms. off St. Agnes, Scilly Is." The material from this same dredging off the Little Orme contained also several other rare species, viz., *Artotrogus magniceps*, *Zaus goodsiri*, *Thalestris hibernica*, and *Thalestris helgolandica*, the last named being also new to our district. On the "Mavis" expedition of June 20th *Anomalocera patersonii* and *Pontella wollastoni*, both notable species, were taken in the tow-nettings about 20 miles off Southport (see also p. 29).

Mr. A. O. Walker gives me the following additional list of Higher Crustacea taken in our district since his last report dealing with the subject:—Schizopoda, *Nyctiphanes norvegica*, M. Sars (off Puffin I.), *Leptomysis lingoura*, G.O. Sars (Colwyn Bay), *Siriella armata*, M. Edw. (off Puffin I.); Cumacea, *Cumopsis goodsiri*, v. Ben. (off Puffin I.), *Eudorella truncatula*, Bate (off Puffin I.); Amphipoda, *Hyperoche lütkeni* Bovall. (tow-net on D. buoy near Puffin I.), *Gitana sarsi*, Boeck (off Little Orme), *Ptilocheirus pectinatus*, Norman (Menai Straits, "Hyæna" cruise, 1890), *Podocerus cumbrensis*, S. and R. (Menai Str. and Colwyn B.), *Erichthonius difformis*, M.

Edw. (I. of Man, "Hyæna," electric light, 1888), *Siphonæcetes typicus*, Kr. (Little Orme), and *Guernea coalita*, Norman (off Great Orme).

Land Mollusca.

In several previous reports Mr. A. Leicester's work on the Land Mollusca at Puffin Island has been alluded to. During the last year he has made two special expeditions to the island, and has been indefatigable in his search, exploring the bushes, tufts of grass, and rock crannies high and low from unconscionably early hours before breakfast till dark night, and leaving literally not a stone unturned in his track. He is now supported in his labours by the Rev. T. Shankland, formerly of the University College of Bangor, now at Mold, who made three or four trips to Puffin Island during July and August for the purpose of comparing the molluscan fauna with that of Anglesey and North Wales, and for the purpose of introducing certain species not found on the island. Altogether they have found during the year 22 species of land Mollusca on Puffin Island, of which 5 are new records (including *Amalia marginata*, *A. gagates*, and *Vertigo pygmæa*).

Mr. Shankland has drawn up comparative lists showing which of the British genera of Pulmonata have been found (1) at Puffin Island, (2) on Penmon Point, Anglesey, and (3) on the Great Ormes Head, as follows :—

Testacella			not found at all.
Arion		Penmon	Great Orme.
Amalia	Puffin	Penmon	Great Orme.
Limax	Puffin	Penmon	Great Orme.
Succinea		Penmon	Great Orme.
Vitrina	Puffin	Penmon	Great Orme.
Zonites	Puffin	Penmon	Great Orme.
Helix	Puffin	Penmon	Great Orme.

Bulimus.....Puffin.....Penmon.....Great Orme.
Pupa .....Puffin.....Penmon.....Great Orme.
Vertigo .....Puffin.....Penmon.....Great Orme.
Balea..... ...not found at all.
Clausilia.....Puffin.....Penmon.....Great Orme.
Cochlicopa.....Puffin.....Penmon.....Great Orme.
Achatina.....not found at all.
Carychium.....not found at all.
Acme.....not found at all.
[*Cyclostoma*.....Great Orme.]

As was to be expected, this list shows a close similarity between the three districts. Mr. Shankland also investigated and arranged the varieties of *Helix nemoralis* on the island. He found 14 distinct band-varieties, several of them very rare ones, and he remarks in regard to this species "I have never met with such a variety and richness of colour." On August 19th and 20th Mr. Leicester and Mr. Shankland were occupied in planting in appropriate spots (all duly recorded in the journal at the laboratory) batches of the following species, which ought to do well on the island, and which they had brought over in considerable quantity from the mainland, viz., *Arion ater*, *Arion hortensis*, *Arion subfuscus*, *Arion bourguignati*, *Limax flavus*, *Limax maximus*, *Amalia marginata*, *Helix aspersa*, *Helix rufescens*, *Cochlicopa tridens*, and *Carychium minimum*.

Faunistic Work at Puffin.

Our first visit in this year to Puffin Island was at the end of February, when three members of the Committee went down to the Biological Station for a few days, partly for the purpose of collecting animals on the shore, and partly to examine into the condition of the boats, the fresh water cistern, the rain gutters on the roof, &c., and give directions to the keeper.

After sailing down from the port of Bangor, taking surface gatherings on the way, we reached the island in good time for the evening low tide, and spent the hours till dark collecting amongst the reefs and boulders of the South Spit. One of the first objects found on the shore was a rather interesting specimen. It was an example of the common limpet *(Patella vulgata)*, which, in place of being attached to a rock, was sticking firmly to the rounded surface of a piece of iron bar from a wreck. The limpet was moulded to the surface. Its lower part was strongly concave, and the edge of the shell was curved up in the middle on each side, and down at each end, so as to be able to embrace about half the circumference of the cylindrical bar. The animal had evidently grown so as to stick closely and tightly to the surface. Now, this would not be at all surprising in a coral or an ascidian, or any animal which remained adhering to one spot all its adult life; but it is remarkable in a case like the limpet, which, it is generally supposed, does not remain rooted to one spot, but wanders about in search of food.

Although when we notice limpets on rocks between tide marks they are generally fixed and motionless, still Prof. J. R. A. Davis has shown that they can loosen their hold and crawl over the rocks for some distance. It is noticed, however, that when the rock is not very hard, as, for example, in the case of the limestone blocks at Puffin Island, each limpet occupies a well-marked depression exactly its own shape. From this it is clear that the animals are not on mere temporary resting places, but are in their own "roosts" or homes, to which, if they leave them, they return regularly, and which they have themselves excavated to a considerable depth and with the precise shape of the outline of their own shells. So much so that they have to place themselves with the

head always facing the one way in order that they may fit into the depressions.

It is not yet known by what sense the limpets are able to find their way back to their roosts when they leave them in search of food. It is certainly not by sight, as the eyes are very simple and imperfect. It has been proved by experiment that it is not by smell; while taste, and feel can scarcely help. There may be a sense of direction different from anything we know of in our own experience; but what the exact method is by which the limpet finds its way about, can go back the way it has come, and can recognise its own roost amongst a number of similar neighbouring depressions, has still to be discovered.

Now for the interest of the present specimen. It is so closely moulded to the iron bar that I am of opinion that it could not have been in the habit of leaving its home and prowling about. In the first place, the bar was short, and was loose, and free to roll about, and it would be very difficult for a crawling snail-like animal such as the limpet to cross from the bar to the rocks even if its support was stationary, but if, as seems likely, the bar was being rolled about by the waves, one does not see that it would be possible for the limpet to re-find its roost, if it ever left it. Possibly, however, as some think, the limpet never loosens its hold when covered by the tide. This would remove the difficulty partly but not wholly. Then, in the second place, the shape of the shell in this specimen is such that I do not see that the animal could crawl over the rocks, or could occupy any position other than that on the bar in which we found it.

After examining this specimen, I looked carefully at the limpets scattered over the rocks, and found several in which the animal was situated at the bottom of a deep pit, from which it would be very difficult, if possible

at all, for it to extricate itself; and one in which the shell was so jammed in between projecting points of rock round which it was moulded, that I was not able even with the careful use of a strong knife-blade to get the shell out entire. Whether the limpet is sometimes able to obtain sufficient food by raising slightly the edges of its shell I cannot say, but certainly the last few cases mentioned seem to prove that individuals now and then fix themselves in positions which after a time they cannot leave on account of the growth of their shells.

For the rest, our programme at Puffin Island was much as usual. We bathed about 7.30 a.m., and collected specimens on the rocks at low tide for an hour or so before breakfast; Mr. Thompson took tow-nettings from the punt round the shore, and Mr. Leicester searched the cliffs and the bushes for land mollusca. We examined into the condition of the boats, the rain gutters on the roof, and the water cistern, and made arrangements for the necessary repairs. Finally, we gave instructions to the new keeper in regard to the tinned meats and other stores to be laid in, and the best way of providing meals for the biologists who might be going down to work at the station during the Easter vacation.

One noticeable feature of the shore at this time was that the specimens of *Littorina rudis*, which are so very abundant in summer and autumn on the rocks above high water mark, were now almost entirely absent. The only ones left were a few odd individuals down at bottom of deep clefts and crevices, perhaps unable to get out.

On April 8th, Dr. Hanitsch went down to Puffin Island to work at Sponges. He obtained *Tethya lyncurium* and *Raspailia ventilabrum* which had not been found on the island before and also three other species new to the dis-

trict, all from the walls of the sponge caves on the north side.

On April 11th, Mr. Thompson and I went to join Dr. Hanitsch for a few days in his sponge hunting. We thought we had experienced all possible methods of reaching St. Seiriol's Isle, except, perhaps, by means of a balloon or a submarine tunnel, but this occasion showed that our resources were not yet quite exhausted. When we arrived at Garth Ferry we found a rough sea, with a strong head wind, and our man in a small ten-foot punt, while the large boat we had expected to meet us was delayed further up the straits, and could not be brought down for some hours. No other boat of sufficient size was obtainable, and the boatmen and pilots at the ferry declared that there was a big sea running beyond Beaumaris, and that it would be impossible for anyone to reach Puffin for some hours at least, until the tide had ebbed, and the sea and wind had fallen considerably. But as we had determined to be at the island, and make various preparations before the low tide, our prospects looked rather blank, and we were just on the point of starting off overland through Anglesey to Penmon, in the hope of being able to get a boat there, and approach our destination from the opposite side, when we fortunately caught sight of a small steamer out in the channel with steam up, and in process of weighing anchor. To jump, all three of us, into our punt with our bags and collecting bottles and other impedimenta, and start in pursuit of the steamer was the work of an instant, and apparently caused no little amusement to the assembled natives on the pier. We pulled furiously, shouting as we went, and waving our handkerchiefs, but our hearts sank as the anchor appeared above the water, the screw began to revolve, and the steamer moved rapidly away from us. Our final yell, however, reached its des-

tination, and with joy we saw the burly captain on the bridge turn round, look at us for a moment, and then apply his mouth to the speaking tube, and we fancied we almost heard the obvious "stop her," which enabled us two minutes later to dash alongside the steamship St. Seiriol (most appropriately named), and, fastening our painter round her rail, clamber on board, state our case, and claim the protection and help of our patron saint with such success that Captain Hughes most kindly welcomed us, and agreed to tow our little punt down to somewhere near Puffin Island. The St. Seiriol was bound to Dingwall with a cargo of slates. A good little boat she is, with a worthy captain, and we had half a mind to go the whole round in her. However, business is business, and the lowest spring tide of the year was awaiting us, so after photographing Captain Hughes and the crew with our Kodaks, we were cast off in the little punt in the middle of the stormy channel, through which the tide runs with great force, between Anglesey and Puffin, and so we made our way to the shore, to the great astonishment of Dr. Hanitsch, who did not expect to see us till some hours later.

During the remainder of our stay the weather was perfect. In fact, on the second day it was so calm that in the evening at low tide we were able to row into the wonderful "sponge caves" on the north side (which can only be entered at the lowest of tides and on a calm day, and then only in a small boat), and inspect their treasures. The two large caves are close together, and have been hollowed by the sea out of the bases of the high limestone cliffs. Their mouths face seawards towards the Irish coast, and on entering the boat has to be pushed (it is too narrow to row) through a long tunnel-like passage, with vertical walls, to the inner end, with its small piece of sloping gravel

beach, where one can land—in the dark. On striking a match it is seen that the sides of the cave are closely encrusted with various kinds of colonial and sessile animals, especially with sponges, the characteristic feature of the place. Here Dr. Hanitsch revels in *Pachymatisma johnstoni*, *Dercitus bucklandi*, *Plumohalichondria atrosanguinea*, and other many-hued slimy-looking Tetractinellids and Monactinellids. Here he first found, a few years ago, the rare new genus which has been named "*Seiriola*," in honour of our sainted predecessor on the isle (probably a good biologist according to the lights of his day and generation), who lived, as the naturalist always loves to do, beside the sea, the rocks, and the Puffins, and who possibly shoved his coracle on a calm evening into the sponge caves and saw in the dim light those curious white masses on the rock which some thirteen centuries after were dedicated to his memory.

The calm weather also enabled us to land upon the Beacon rocks and explore their recesses and fissures. By the way, why has this beacon, standing on a dangerous rock surrounded by strong currents and eddies, in a channel frequented by fishing boats, flats, and other small coasting craft, not got any means by which a man reaching its base might cling on for a time or even climb to the top? A close-fitting iron ladder and a few rings and hooks would probably offer but little opposition to the flow of water over the smooth rounded masonry, and might at any time be the saving of the occupants of a boat carried against the rocks or upset in the immediate neighbourhood of the beacon.

While suggesting improvements, I may be allowed to point out the excellent opportunity which the walls of our biological station would offer to an art teacher, and say half a dozen students, for the planning and carrying out

of schemes of decoration. Some simple artistic designs, applied in co-operation, under the direction of the teacher, might convert our wide expanses of whitewashed walls in the rooms, and the broad yellow planks between and around our sleeping bunks, into things of beauty, which would be a joy for ever to the sojourning biologists, and a constant reminder that there is something else in the world besides science, and another side to nature from the one they are especially observing in the field and in the laboratory. We have made a feeble beginning by cutting our initials on the front of the bunks we usually occupy, and by labelling the head planks with their official designations, such as "hon. treasurer's bunk;" but there is still abundant opportunity for further decoration.

One of the most interesting animals obtained this time was the sea slug *Dendronotus arborescens* of which a specimen was dredged in the channel about a quarter of a mile off the south-west end of the island. This animal is not uncommon at many places round our coast, but the special interest of this particular one is as follows:—Until lately *Dendronotus* has not been found anywhere near Puffin. Five years careful shore-collecting and dredging in the neighbourhood failed to turn up a single specimen. At Hilbre Island, on the other hand, this magnificent sea slug is abundant, and forms one of the most characteristic features of the fauna. With the view of introducing this, which is certainly the finest of our British nudibranchs, at Puffin two separate batches were taken down alive from Hilbre in September, 1888, and were set free at low tide on the South Spit. They had disappeared before the next tide, and all further search for them or their progeny, both by sea and shore, during the following two years was fruitless, and we were beginning to think that the experiment had failed. During the "Hyæna" cruise of last

summer, however, when dredging in the straits between Puffin and Beaumaris, we brought up one very young specimen of *Dendronotus*, which, if it had any connection with the specimens from Hilbre, was only one of their descendants, and now we have found another *Dendronotus* of much larger size, but still not quite full grown, close to Puffin Island. These are, perhaps, too slender grounds for drawing any definite conclusion from, but it is at least quite possible that these specimens may be descended from those set free in September, 1888, and if so, the species is probably now established in the neighbourhood of Puffin Island, and may be expected to turn up frequently in our future operations.

We collected altogether on this occasion 13 species of Nudibranchs, including the rare *Eolis landsburgi*; also a very remarkable sponge belonging to the genus *Suberites*, and another sponge of a dark orange colour—one of the Desmacidonidæ—which was found by Dr. Hanitsch in one of the caves. This will probably turn out to be a very rare and interesting sponge as it is in symbiosis with a Zoophyte. The hydrorhiza of the Zoophyte permeates the sponge in all directions and replaces to a certain extent the missing spongin fibres. The spicules of the sponge are found echinating the hydrorhiza of the Zoophyte. The only other notable sponges obtained from Puffin during the year were an undetermined species of *Desmacidon* from the caves, and a *Chalinopsis* found washed up, by the keeper, in February.

The first Puffin was seen by the keeper on the island on April 9th, Dr. Hanitsch saw 2 or 3 on April 10th, and we all saw several pairs on April 12th.

At the end of June and beginning of July Mr. W. Thornely and Mr. F. V. Milward from Cambridge were at the station collecting Zoophytes and Polyzoa. Of the

former group they obtained 24 species, of which 4 (including *Eudendrium rameum*) were new to Puffin Island. Of Polyzoa 19 species and 2 varieties were found, and of these 1 species (*Schizoporella unicornis*, only found previously in our district at the Isle of Man) and 1 variety (*Pedicellina cernua*, var. *glabra*) were new to Puffin.

The visit of Dr. G. S. Brady and Mr. I. C. Thompson to Puffin in July for the purpose of studying the Copepoda resulted in the capture of 2 species of Copepods new to the district, dredged from a depth of 10 fms., off the north side of the island, viz., *Pontella acuta*, Dana, and *Misophria pallida*, the first being new to Britain and not before recorded north of the Indian Ocean. The same dredging contained 2 specimens of another rare species *Cyclopicera lata*, Brady.

Early in August two former students of the Biological department of University College, Liverpool, and graduates in Science of Victoria University, Miss Amy Warham and Miss Lucy Buckley, went to Puffin for the purpose of collecting compound Ascidians and making some observations upon them in the living state. I extract the following from their record in the journal as a sample :—

"Aug. 5th. Morning, collecting on shore under house. After breakfast went dredging with flood tide along north side of island towards Conway Bay—dredge full of Ascidians, Zoophytes, Hermit-crabs and Sea-urchins. Arrived back at 4 p.m. After tea, shore-collecting on spit —most beautiful sunset. Examining and sorting the material dredged, in evening. Station very comfortable and clean."

"Aug. 6th. Left by morning tide and intend having a haul of the dredge in the straits."

Faunistic Work at Hilbre.

As usual members of the Committee and others have tried to go to Hilbre Island at the very low tides as often as possible during the year. On a visit in April Mr. Christophers, a student of the Biological department of the College, found a species of sponge (*Raspailia* sp.) which is at least new to the district. We also on that occasion obtained various Nudibranchs, some of them spawning. The starfishes were very abundant on the rocks, and seem to be yearly increasing in number. Young mussels were also at this time very plentiful all over the rocks. Later in the year we found that the mussels had entirely disappeared. To some extent no doubt they are eaten by the starfishes and other animals, but we have reason to believe that their disappearance as they get large is chiefly due to the fact that on account of the layer of fine mud which covers all the rocks at Hilbre they are unable to attach themselves firmly to any solid support and merely cling together by the interlacing of their byssus fibres, so that when they come to be of appreciable size and offer resistance to the sweep of the waves, they are readily detached from the surface of the rock in large sheets a yard or two in length. We have seen this process going on on more than one occasion—the sheets of half-grown mussels being rolled up by the waves, and then washed about the sands.

On November 14th some of us went to Hilbre Island with Professor Howes (S. Kensington), Mr. Garstang and Mr. Bles (Owens College) and some others, when we found 8 species of Nudibranchs, *Garveia nutans*, a *Siphonostomum*, the Nemertean *Amphiporus lactifloreus*, and other interesting forms.

The amount of Zoophytes and Polyzoa found cast up by the recent gales was most astonishing. A few hand-

fuls of these brought home have been examined by Miss L. R. Thornely who finds in them 18 species of Polyzoa, of which 3 (*Cellaria fistulosa*, *Cellepora avicularis* and *Bowerbankia pustulosa*) have not been previously recorded from Hilbre; and 22 species of Zoophytes of which 8 are new to the locality.

The Shrimp Enquiry.

The collection of statistics in regard to the life-history and habits of the common shrimp (*Crangon vulgaris*) in this neighbourhood has been continued for a second year. The circulars asking a few simple questions such as a shrimper could readily answer were taken charge of at the five fishing centres by the same gentlemen who kindly helped me in the matter last year, viz., Mr. T. Comber, F.L.S., and Mr. Comber, Junr. (Parkgate), Mr. R. L. Ascroft (Lytham), Mr. A. Leicester and Dr. Chaster (Southport), Mr. A. G. Haywood (Crosby), and Mr. Henry Isaacs (Hoylake); and most of the circulars have been returned to me, duly filled up, with regularity throughout the twelve months. I wish to express my acknowledgments to all those friends for their hearty co-operation. I know a few of them have had some difficulty and trouble in collecting the information—for example, one of my correspondents writes to me that he could not get continued replies to the enquiries "because a tory canvasser spread the report that I had a political purpose in view."

The questions asked for each month were:—"(1) Have shrimps been plentiful this month; what was the average catch per boat? (2) Were they of large size? (3) Were any young or immature ones seen? (4) Had any of them eggs? (5) In what locality were they caught? (6) In what depth of water, and on what bottom? (7) What

were the shrimps feeding on? (8) Did you see anything eating the shrimps? (9) What has been the general weather and state of sea this month? (10) Have you any other remarks to make?"

Last year I reduced the reports to a tabular form* showing the answers to each question in each month at each locality. There is no need to construct a similar table this year as on the whole the answers are the same as before, I shall therefore refer readers to last year's table and mention merely the few points of difference or of special interest which these reports present.

In January, in all localities, the shrimps were smaller than in the previous year: the weather was colder, frosty. Mr. Ascroft writes from Lytham in February that there are "a great number of *Crangon allmani* amongst the shrimps."

The prawners are reported as finding lumps of the sand tubes built up by the gregarious annelids *Sabellaria alveolata* to be full of prawns. This year again there is much evidence that few shrimps are to be obtained in cold and in unsettled weather. The food matters generally attributed to the shrimps are:—worms, shore worms, long fine green worms, dead fish, sweet cockles and lug-worms, stones and shells, and finally "suction." One correspondent mentions that sometimes the anterior end of the shrimp is coloured green by the green worms it has eaten. Some of these matters require investigation.

By universal consent the worst enemies of the shrimp are crabs (*Carcinus moenas* and *Polybius henslowi*) and fishes, especially whiting, young haddock, small cod, skates, and flukes. Mr. Ascroft mentions in February having taken a quart of shrimps out of a skate's stomach. It is reported from Parkgate that in the summer time the

* See Trans. L'pool Biol. Soc., vol. v., p. 32, 1890.

hand or push nets kill great numbers of young shrimps in the shallows; and there certainly seems abundant evidence that a great destruction of immature flat fish (soles and flukes) is caused by the shrimpers generally. It is worth consideration and experiment whether it would be possible to construct in the tail end of the net some form of metal sieve with narrow elongated meshes of such a size and form as would allow small soles and flukes to wriggle through while retaining at least the larger shrimps. This would be in constant action while the net was being worked, and would take the place of the apparently inadequate operation of sifting, which is performed in the boat after the net has been emptied and which is probably too late to save the lives of many of the young fishes. Mr. R. A. Dawson has just informed me that a few years ago he experimented with a shank trawl which had the lower edge of the net fixed to a bar set a little way off the ground so that only the shrimps, which spring well upwards when disturbed, were captured and most of the young fishes were passed over. Mr. Dawson intends to have another net of this kind made, and to give it a fair trial during the fishery investigations he is now carrying on.

If, as seems likely, it will be soon found necessary in the interests of the young flat fish to restrict somewhat the operations of the shrimpers in space or time, or in both, a compensating addition to the supply of shrimps might, I think, be obtained by artificial cultivation. Some parts of our sandy estuaries might be enclosed as shrimp preserves to be stocked, supplied with food, and carefully attended to. The shrimps breed practically all the year round, are hardy and prolific, and if supplied with plenty of food and protected from their enemies would probably increase greatly in numbers in a very short time.

In discussing this matter lately with Mr. A. O. Walker, he suggested that without going so far as a definite scheme of artificial cultivation, a good deal might be effected by selecting as breeding grounds certain portions of the coast, say one mile in length and extending from the shore out to a depth of a few fathoms, on which large stones should be put down a hundred yards or so apart in order to prevent any trawler from working on those areas. This would be a very inexpensive method of making what would probably form an admirable and safe breeding ground for both shrimps and fish.

Other Investigations.

Mr. Chopin of Manchester did some collecting work at the south end of Isle of Man in August, and succeeded in finding *Lucernaria* which had not previously been recorded in our district. He also made a collection of sponges which Dr. Hanitsch, who is examining them, reports will probably be found to contain 2 or 3 species new to the neighbourhood.

Mr. G. Swainson of St. Anne's has been indefatigable in tow-netting at night from the end of the pier, and has been rewarded by the capture of a number of interesting forms of surface life, including the Tunicata *Fritillaria furcata*, not previously recorded, and a form of *Oikopleura* with a remarkable investing test or "Haus" on which Mr. Swainson read a paper at the Cardiff meeting of the British Association.

Specimens collected at Puffin Island and elsewhere have, as usual, been distributed to our specialists, and have afforded material for a number of investigations which have been or will be shortly laid before the Biological Society. A small collection of typical marine Invertebrata has also been sold to the Yorkshire College,

Leeds, for laboratory use. The Committee would be glad to add to the income of the Station in this way in the future. Most ordinary marine types for laboratory work can be supplied either fresh or preserved in spirit.

The usual balance sheet is appended, by the Hon. Treas., along with a list of the subscriptions and donations to the L.M.B.C. funds received during the last year.

Applications* to be allowed to work at the Biological Station, or for specimens (living or preserved) for Museums, Laboratory work, and Aquaria, should be addressed to Professor Herdman, University College, Liverpool.

Subscriptions and Donations should be sent to Mr. I. C. Thompson, F.L.S., 19, Waverley Road, Liverpool.

The L.M.B. Committee are publishing their Reports upon the Fauna and Flora of Liverpool Bay in a series of 8vo. volumes at intervals of about three years. Of these two have appeared:—vol. I. containing 372 pp. and 12 plates, price 8/6, was issued in 1886; vol. II. containing 240 pp. and 12 plates, price 7/6, was issued in 1889. Vol. III. is nearly ready and will be issued in the summer of 1892. Copies of these may be ordered from the Liverpool Marine Biology Committee, University College, Liverpool, or the Hon. Treas., 4, Lord Street, Liverpool.

*Subscribers of a guinea or upwards to the funds are entitled to work at the Station, when there is room, free of charge (except the keeper's weekly account for food) College Students of Biology are offered lodging (not including food) and the use of the laboratory at the Station at the rate of ten shillings per week, payable to the Hon. Treasurer. All visiting the Station, including Members of the Committee, Subscribers, and Students, pay the keeper daily or weekly for their food. Four simple meals (breakfast, dinner, tea, and supper) are provided at about cost price, averaging three shillings a day.

Appendix.

SUBSCRIPTIONS and DONATIONS.

	Subscriptions.			Donations.		
	£	s.	d.	£	s.	d.
Archer, Francis, B.A., 21, Mulgrave-street	1	1	0		—	
Banks, Prof. W. Mitchell, 28, Rodney-st.	2	2	0		—	
Bickersteth, Dr., 2, Rodney-street... ...	2	2	0		—	
Brook, George, 19, Greenhill-gardens, Edinburgh	1	1	0		—	
Brown, Prof. J. Campbell, University College, Liverpool	1	1	0		—	
Brown, J. Harvie, Dunipace House, Larbert, N.B....	0	10	0		—	
Bulley, Arthur K., West Kirby	1	0	0		—	
Burton, Major, Fryars, Beaumaris... ...	2	2	0	2	2	0
Caine, Nath., 10, Orange-court, Castle-street	1	1	0		—	
Caton, Dr. 31, Rodney-street		—		1	1	0
Comber, Thomas, Leighton, Parkgate ...	1	1	0		—	
Coventry, Joseph, 34, Linnet Lane ...	1	1	0		—	
Davidson, Dr., 2, Gambier-terrace... ...	1	1	0		—	
Denny, Prof., Firth College, Sheffield ...	1	1	0		—	
Derby, Earl of, Knowsley	5	0	0		—	
Drysdale, Dr., 36A, Rodney-street... ...	1	1	0		—	
Gair, H. W., Smithdown-road, Wavertree...	2	2	0		—	
Gamble, Col. David, C.B., Windlehurst St. Helens	2	0	0		—	
Gaskell, Holbrook, J.P., Woolton Wood, Much Woolton	1	1	0	1	0	0
Gibson, R. J. Harvey, 41, Sydenham-avenue	1	1	0		—	
Gifford, J., Whitehouse-terrace, Edinburgh	1	0	0		—	
Glynn, Dr., 62, Rodney-street	1	1	0		—	

Halls, W. J, 35, Lord-street	1	1	0	—		
Henderson, W. G., Liverpool Union Bank	1	1	0	—		
Herdman, Prof., University College, L'pool.	2	2	0	—		
Higgin, Thos. (the late), Ethersall, Roby...	1	1	0	—		
Holder, Thos., 1, Clarendon-buildings Tithe-barn-street	1	1	0	—		
Holland, Walter, Mossley Hill-road ...	2	2	0	—		
Holt, George, J.P. Sudley, Mossley Hill ...	1	0	0	—		
Johnstone, Rev. Geo., M.A., 41, Bentley-rd.	0	5	0	—		
Jones, Chas. W., Field House, Wavertree	5	0	0	—		
Jones, Mrs. Chas. W., Field House, Wavertree		—		5	0	0
Jones, J. Birdsall, 10, St. George's-crescent	1	1	0			
Leicester, Alfred, 24, Aughton-rd, Birkdale	1	1	0	—		
Lomas, J., 23, Avondale-road	0	10	6	—		
Macfie, Robert, Airds	1	0	0	—		
Marshall, Prof. A. Milnes, Owens College Manchester	1	1	0	—		
McMillan, W. S., 17, Temple-street ...	2	2	0	—		
Meade-King, R. R., 4, Oldhall-street ...	0	10	0	—		
Meade-King, H. W., Sandfield Park, West Derby...	1	0	0	—		
Melly, George, 90, Chatham-street... ...	1	0	0	—		
Melly, W. R., 90, Chatham-street... ...	1	0	0	—		
Miall, Prof., Yorkshire College, Leeds ...	1	1	0	—		
Monks, F. W., Brooklands, Warrington ...	1	1	0	—		
Muspratt, E. K., Seaforth Hall	5	0	0	—		
Phillips, Prof. R. W., Univ. College, Bangor	1	1	0	—		
Poole, Sir James, Tower Buildings ...	2	2	0	—		
Rathbone, R. R., Glan-y-Menai, Anglesey	2	2	0	—		
Rathbone, S. G., Croxteth-drive, Sefton-park	2	2	0	—		
Rathbone, Theo., (the late,) Backwood, Neston	2	2	0	—		
Rathbone, W., M.P., Greenbank, Allerton	2	2	0	—		
Roberts, Isaac, F.R.S., Tunbridge-wells ...	1	1	0	—		
Shankland, Rev. Thos., Wheat-villa, Rhyl	0	10	6	—		

Shepheard, T., Kingsley Lodge, Chester ...	1	1	0	—		
Simpson, J. Hope, Annandale, Aigburgh-drive	2	2	0	—		
Smart, Rev. E. H., Kirby-in-Cleveland, Northallerton	1	1	0	—		
Stewart, W. J., City Magistrates Office	1	1	0	—		
Tate, A. Norman, 9, Hackin's-hey... ...	1	1	0	—		
Thompson, Isaac C., 19, Waverley-road Sefton-park	2	2	0	—		
Thornely, James, Baycliff, Woolton ...	1	1	0	—		
Thornely, The Misses, Baycliff, Woolton ...	1	0	0	—		
Toll, J. M., 340, Walton Breck-road	1	1	0	—		
Vicars, John, 8, St. Alban's-square, Bootle	2	2	0	—		
Walker, Alfred O., Nant-y-glyn Colwyn Bay	3	3	0	—		
Walker, Horace, South Lodge, Princes-park	1	1	0	—		
Watson, A. T., Tapton-crescent, Sheffield	1	1	0	—		
Westminster, Duke of, Eaton Hall ...	5	0	0	—		
Wiglesworth, Dr., Rainhill	1	0	0	—		
	100	10	0	9	3	0
Royal Society Grant, per Professor Herdman ...				50	0	0

LIVERPOOL MARINE BIOLOGY COMMITTEE.

Dr. IN ACCOUNT WITH ISAAC C. THOMPSON, HON. TREASURER. Cr.

1891.	£	s.	d.
To Balance due Treasurer, 1890	3	13	8
,, Salary of Keeper	52	0	0
,, Station Repairs	3	13	1
,, Repairs to Boats, Ropes, Chains, &c.	6	1	5
,, Cutter, "Morning Star"	20	0	0
,, Steam Tugs, and Dredging Expenses	25	6	11
,, Postages, Carriage of Apparatus, Specimens, &c.	3	17	4
,, Paraffine Oil and Coals	7	19	0
,, Printing and Stationery	20	2	6
,, Sundries	2	9	7
	£145	3	6
By Balance due Treasurer	3	0	6

1891.				£	s.	d.
By Subscriptions and Donations	£107	1	0			
Of which £25 is towards Endowment and placed to Investment Account.	25	0	0	82	1	0
,, Grant from Royal Society				50	0	0
,, Dividend, British Workman's Public House Co., Ltd., Shares				4	10	0
,, Sale of Marine Specimens				1	8	0
,, Reports				0	10	6
,, Amount collected on S.S. "Mavis"				3	13	6
,, Balance due Treasurer				3	0	6
				£145	3	6
Endowment Fund Investment, British Workman's Public House Co.'s Shares.				80	0	0
Funds pending Investment				25	0	0
				£105	0	0

ISAAC C. THOMPSON,
HON. TREASURER.

LIVERPOOL, 31*st December*, 1891.

Audited and found correct,
ALFRED LEICESTER.

NOTES on the STRUCTURE of OIKOPLEURA.

By W. A. Herdman, D.Sc., F.L.S.,

PROFESSOR OF NATURAL HISTORY IN UNIVERSITY COLLEGE, LIVERPOOL.

With Plates I—IV.

[Read 12th February, 1892.]

For several years, as opportunity offered, I have been making occasional observations on the structure of Appendicularians, living and preserved, from Puffin Island and other parts of Liverpool Bay. Mr. G. Swainson, F.L.S., of St. Annes-on-the-Sea, Lancashire, who has been successful in capturing several curious forms of Appendiculariidæ, lately sent me for examination a very good specimen of an *Oikopleura* (probably *O. flabellum*, J. Müll.) which he had caught in his surface net from St. Anne's pier in August, and had preserved in graduated alcohols from 30°/₀ to absolute, and which had been imbedded in paraffine, stained with Babes' safranin solution and sectionised by Dr. E. C. Bousfield with the Caldwell automatic microtome. My thanks are due to Mr. Swainson and Dr. Bousfield for their kindness in enabling me to examine this form. As their specimen seems to have been in excellent condition, and shows some interesting points rather well, I have made it the basis of the following observations (in which the substance of my former notes is incorporated) and have drawn in the accompanying plates the more important of the sections, enough of them, I think, to form a guide to the complete structure of the animal. I have also given in figure 9 on plate IV. a lateral view of the animal, reconstructed from the serial sections, which may be useful in interpreting the individual

sections, and also as an approximately true-to-nature diagram of the typical structure of the group. The structure of various Appendiculariidæ examined whole as transparent objects has been described and figured by Huxley, Gegenbaur, Fol, Eisen, Sanders, Moss, Chun and others, but the method of serial sections has not apparently been applied before to this group, and I do not think any figures of sections have yet been published.

The size of the specimen was:—length of the body 1.5 mm., and length of the "tail" 4—5 mm. On commencing at the rounded posterior end of the body (see Pl. IV. fig. 9) it is found that the first few sections consist of ovary alone surrounded by a delicate membrane, the ectoderm. There is no trace of cuticular test on this part of the surface. Then, after a few sections, a small crescentic or lenticular piece of testis begins to appear on each side of the ovary and gradually increases in size as it is traced forwards. Consequently in some sections near the posterior end (see Pl. I. fig. 1) the ovary seems to be a single median organ placed between a pair of lateral testes. In a few sections considerably further forward, however, (Pl. II. fig. 2) we find two lateral pieces of ovarian tissue, while the testis is a single organ. The fact is both are single, but lobed: the ovary being slightly bifurcated at its anterior end and having an overhanging dorsal lobe near its posterior extremity (see Pl. IV. fig. 9, *ov*), while the testis consists of two great posterior lateral lobes connected anteriorly and ventrally (Pl. II. fig. 3, *sp.*).

The outlines of the ova are not distinct, but the germinal vesicles and germinal spots are very conspicuous even under a low power (Pl. I. figs. 1, 2, &c.), while a higher magnification shows them as represented in Plate I. fig. 4. The spermatic tissue in the testis shows merely a number of fine rounded dots in a faintly stained protoplasm, the

dots being evidently the deeply stained nuclei of the small spermatic cells (see Pl. I. figs. 3 and 5).

After about 20 sections from the posterior end the lateral lobes of testis are found to be encroaching upon the ovary in its centre so as to divide off a smaller dorsal lobe from the ventrally placed main mass (Pl. I. fig. 2). In this region is found the apparently single genital duct. The dorsal ectoderm bends down in section 24 to form a slender epithelial tube which seems to join the wall of the ovary (Pl. IV. fig. 9, *o.d.*). The testis lobes come in contact dorsally at this point and may possibly join (Pl. I. fig. 3), so the tube might be vas deferens, or act both as oviduct and vas deferens. The dorsal lobe then dies out after a few sections, and the ovary is then represented by a nearly flat ventral plate which can be traced forwards to about the 90th section (counting from the posterior end). Figure 3 on Plate I. shows the typical arrangement in a number of sections, say numbers 25 to 45, where the ventral ovary and the two lateral testis lobes enclose a small triangular area, which will be occupied a little further forward by the alimentary canal. The whole is still surrounded by a delicate ectoderm with no trace of a distinct test.

The next figure (Pl. I. fig 6) shows, in the 48th section, the most posteriorly placed part of the alimentary canal. It is a short dorsal diverticulum from the point where the œsophagus joins the stomach, and can be traced forwards through the sections into the œsophagus and then the pharynx or branchial sac. In about the 50th section we come upon the first trace of the test in the form of a thin layer of cuticle dorsally placed and co-terminous with an area of rather larger ectoderm cells. As one traces the sections forwards these ectoderm cells get larger, and the layer of test over them becomes thicker (see Pl. I. figs. 7

and 8). Inside the ectoderm on this dorsal aspect a very thin layer of connective tissue (parietal mesoderm) can now be recognised (fig. 8, *mes*).

We now come upon the posterior end of the stomach. This organ is of large size and complicated shape, it extends from about the 50th to the 160th section. There are two great laterally placed posterior lobes which join anteriorly. Into one of these lobes, the left, the œsophagus opens, while the intestine emerges from the other, on the right side. They may be conveniently referred to as the cardiac (left) and the pyloric (right) sacs respectively. These lateral posterior parts of the stomach are of considerable dorso-ventral extent (see Pl. II. fig. 1, *st*, *st'*), while the anterior or median part of the stomach where the cardiac and pyloric sacs join is low, but very wide from side to side (Pl. II. fig. 5). The greater part of the alimentary canal is richly ciliated (Pl. I. fig. 10). I have, however, not been able to find any trace of cilia in the cardiac sac which is very much more glandular, especially in its ventral end (Pl. II. fig. 1, *gl*) than any other part of the stomach.

The pyloric sac extends a little further posteriorly than the rest of the stomach, and is seen in fig 7, Pl. I. with the flattened diverticulum from the œsophagus lying dorsally. In the next figure (Pl. I. fig. 9), which shows the 61st section, the cardiac sac is just beginning to appear below the œsophagus, and ten sections further forward (Pl. I. fig. 10) the two are found to communicate, the œsophagus having turned ventrally with a slight undulation. The pyloric sac is now large and lies with its long axis dorso-ventrally. Its interior, and that of the œsophagus, is ciliated while the cardiac sac shows glandular cells at its ventral end (Pl. I. fig. 10, *gl.*).

The last three figures show the gradual reduction in

size of the lateral testis lobes which now no longer invade the dorsal part of the body; these figures (Pl. I. figs. 7, 9, 10) also show the increase of the dorsal cap of large ectoderm cells and of test both in thickness and in superficial extent. About the 70th section (Pl. I. fig. 10) it may be noticed that the test is becoming thinner in the medio-dorsal line and thicker in its lateral parts. The most posterior (curved) part of the nerve cord (myelon) is seen in figs. 9 and 10. Its two ends diverge, the one (*n.s.*) dorsally and to the right to become continuous anteriorly with the cerebral ganglion, and the other (*n.*) ventrally and to the left to join the caudal ganglion and nerve (compare Pl. IV. fig. 9, *n.*).

Ten sections further forward (Pl. II. fig. 1) the cardiac and pyloric sacs are found to join at their dorsal ends, and from this point forward to its anterior extremity, in section 163 or so, the stomach is seen as a single cavity which gradually diminishes in its vertical and increases in its horizontal (lateral) extent. The œsophagus is still seen running forwards over the stomach dorsally, and the cilia and gland cells are distributed as before. After another ten sections we find that the two lateral testis lobes become connected by a median band immediately above the much reduced ovary which now bifurcates (Pl. II. fig. 2) and then dies away. This last figure shows the constriction marking the separation of the intestine (*i*) off from the pyloric sac.

We now come to the point where the œsophagus passes into the pharynx or branchial sac, and in section 103 (Pl. II. fig 3, *ph.*) it is seen that the lumen of this dorsal cavity has become distinctly triangular with a medio-dorsal groove which is the posterior end of the well marked epipharyngeal groove corresponding to the dorsal lamina of Ascidians. The stomach and testis are much as before,

and the intestine is now seen to be completely separated off from the pyloric sac, while the cæcal extremity of a new tube—a diverticulum running posteriorly and to the left from the rectum is seen in the middle line between the stomach and the intestine. In the next section figured (Pl. II. fig. 4), which is just ten further forward, this diverticulum is seen as a large distinct tube lying near the centre of the body and between stomach and intestine. It can be traced alongside the latter (see Pl. II. fig. 5) for about 20 sections when (Pl. II. fig. 6) the two tubes communicate, and finally after another 20 sections the two have completely coalesced to form a single medio-ventral tube, the rectum. Pl. II. fig. 6 (section 134) shows the two tubes communicating by a narrow passage provided with long cilia; Pl. II. fig. 7 (section 151) shows the tubes almost completely joined there being only a small chink left to represent the intestine, the greater part of the lumen being derived from the diverticulum; finally Pl. III. fig. 1 (section 155) shows the median rectum, still a little unsymmetrical in shape. It results from this arrangement seen in the last 50 sections that there must be only a very narrow slit-like opening from the intestine into the point of junction of the rectum and its cæcum.

These sections (103 to 155) show also the gradual but marked growth of the pharynx in size and differentiation as it is traced forwards. Figures 4 and 5 on Pl. II. and fig. 1 on Pl. III. show the triangular shape, the broad ventral base, the thin lateral walls, and the formation of ciliated tracts dorsally and ventrally, the dorsal being a pair of prominent pads which bound the epipharyngeal groove (see Pl. II. fig. 5, *ep.p.*), while the ventral is a flat hypopharyngeal plate (*hy.p.*) which can be traced forwards to near the endostyle. Section 113 (Pl. II. fig 4) shows the anterior bifurcation of the testis (*sp.*) which dies out

a few sections further forward, thus bringing us to the anterior end of the very extensive hermaphrodite reproductive system (compare Pl. IV. fig. 9).

The gradual increase of the dorsal area of large ectoderm cells, and of the thickened test covering it, is very noticeable, and the point where ectoderm and test join and thin off into a delicate membrane (× in Pl. II. fig. 5) can be seen to advance further and further down the wall of the body until in section 155 (Pl. III. fig. 1) it has almost reached the ventral surface. We are now approaching the anterior end of the stomach. This extensive cavity has been gradually changing its shape in the sections from a vertical bilobed to a single horizontal space lying across the middle of the body (see Pl. III. fig. 1) between the dorsal branchial sac and the ventral rectum. In the next few sections the walls are found encroaching irregularly upon the lumen, and in section 163 (Pl. III. fig. 2) the lumen has completely disappeared, and a couple of sections further forward (Pl. III. fig. 3) no trace of the wall of the stomach is left.

Just before we finally leave the stomach behind we come upon the posterior end (really the morphological anterior part) of the great ventral appendage or "tail" (Pl. III. fig. 1, *app.*). Consequently the tail joins the body just about on a level with the anterior end of the stomach. No trace of the tail is visible in section 125 (Pl. II. fig. 5,) while it is seen just completely separated off from the ventral body-wall in section 155 (Pl. III. fig. 1). It first appears a few sections behind this, and it is the lateral edges of the tail which first become free, and lastly the median part lying between the notochord and the rectum separates off from the ventral wall of the body. From this point the tail is present in all the sections forward to the front or oral end of the body, and even for a considerable

distance beyond that. It contains in its centre the notochord (or urochord, *n. ch.*) and on the left side of that the nerve or myelon (*n.*). In section 155 (Pl. III. fig. 1) we see the latter greatly enlarged to form the caudal ganglion at the base of the tail. The heart is placed just above the base of the tail (Pl. IV. fig. 9, *h.*). We see a part of it between the stomach and the rectum in Pl. II. fig. 5, at *h.*

We now come to the important region, about section 170, where the branchial sac or pharynx communicates with the exterior by a pair of ventral tubular ciliated openings or stigmata. The series of sections represented by figures 3 to 6 on Pl. III show the structure of these openings and the passages leading to them. The first change as one approaches the stigmata is seen at *a* on the right hand side of fig. 3, (section 165) where the lateral edge of the branchial sac bends down ventrally while at the same time the ectoderm on the surface of the body over this region is invaginated, so that only a narrow bridge of tissue is left between the two cavities. The next stage is seen a couple of sections further forward at *b* in fig. 4, where a few large cells appear in the bridge of tissue and then become arranged, as at *c*, in two regular rows. These rows of cells draw apart (see *d*, fig. 5), then additional rows appear till there are in all 4 series of cells with narrow slits between the rows (*e*. fig. 3). [On account of a slight obliquity in the sections or because of one of the stigmata being slightly further forward than the other, the two sides of the body show different conditions in the same section, consequently these four sections figured show us eight or nine different stages (*a* to *i*, figs. 3 to 6)]. The middle cells of each row then die out as we trace the sections forwards (see *f*. fig. 4) leaving merely a set of four pyramidal richly ciliated cells (*g*. fig. 5) on each wall of the tubular passage which places

each side of the branchial sac in free communication with the external world. For some few sections from No. 170 forwards this is the state of affairs, and these sections are evidently cut through the middle of the stigmata. It is clear then that we are dealing with four horizontal rings of ciliated cells encircling the middle of the passage.

Then these passages begin, about section 180, to be closed in by the ectoderm growing across the external aperture, outside the ciliated cells. It is the most ventral extension of the area of large test-producing ectoderm cells which effects this change. In fig. 3 it is seen that the conspicuous ectoderm has exactly reached the lateral angles of the triangular body, immediately external to the openings (atrial) of the stigmata; in fig. 5 a little thickened ectoderm is seen on the ventral surface just internal to these openings; while in fig. 6, at *h* on the right side, the ectoderm is seen to have grown across the opening in the form of a fold from each side; and finally at *i*, on the left side of the same figure, the folds have completely united and there is now a wide bridge of tissue, both covered and lined by ectoderm, separating the remains of the stigma from the exterior. The ciliated cells now die away a few sections further forward leaving the lateral edges of the branchial sac very much as they were immediately posterior to the stigmata (see right side of fig. 3 and fig. 7). This series of sections in which the stigmata are present shows also the rectum changing from a triangular (fig. 3) to a circular lumen (fig. 6), and then opening to the exterior at the anal aperture. Fig. 7 (section 190) is immediately in front of the anus, so the rectum is no longer present.

The ectoderm cells on the lateral walls of the body are becoming still larger and more conspicuous (fig. 7), and they now extend well on to the ventral surface from each

side, leaving only its middle third uncovered. In the dorsal part of the branchial sac the two ciliated pads which further back lay one at each side of the narrow epipharyngeal groove are now seen to have moved further ventrally, and they continue as traced forwards to run obliquely down the lateral walls of the branchial sac (see figs. 7 and 8), being now in fact the peripharyngeal ciliated bands of ordinary ascidians, till finally they meet in the ventral median line in the region of the endostyle. In the middle of the lateral surface of the body (fig. 8) the ectoderm is more than one layer deep. There are large columnar cells,* in each of which several nuclei are present while at the bases of these there are smaller triangular cells with their apices running in between the adjacent columnar ones (Pl. III. fig. 10).

The tail in the last few sections while remaining of about the same width from side to side has become a good deal thicker dorso-ventrally, and the dorsal and ventral surfaces in the middle third have become covered by a thicker layer of ectoderm, while inside that and co-terminous with it is a well marked layer of muscle fibres (see Pl. III. figs. 8 and 9). In the centre of the tail and occupying all the extent between the two muscle layers is the notochord with its usual undulating outline, and on its left side the delicate nerve cord (see Pl. III. fig 7). The tail retains this structure through all the sections forwards to and in front of the oral end of the body proper.

The next section figured, No. 216 (Pl. III. fig. 8), shows the body becoming rapidly smaller, while the ectoderm cells on the lateral walls have become enormous, and

* It is probably these cells which Sanders (Mon. Micros. Jour., Ap. 1874, p. 141) mistook for stigmata in his *Oikopleura* from Torquay. Possibly the supposed gill-slits in Moss's remarkable appendicularian (Linn. Trans. XXVII, p. 299.) may have been either large ectoderm cells or large glandular cells of the endostyle.

show distinctly the arrangement in more than one layer noted above (see fig. 10). The entire ventral surface is now covered with large ectoderm cells, and there is a continuous layer of test all over the body. With the exception of the small dorsal nerve cord (*n.s.*), the branchial sac or pharynx is the only organ inside the ectoderm. It is roughly of triangular form with a ciliated pad projecting inwards from each of its sides. The two lateral pads are the peripharyngeal bands and the third is a median ventral ridge (the hypopharyngeal) which shortly becomes converted into a ciliated groove leading forward to the endostyle. Six or seven sections further on (Pl. IV. fig. 1) this ventral ciliated area is seen as a shallow groove, two sections in front of that (Pl. IV. fig. 2) it has become a deeper, narrower groove, and in another couple of sections it forms, along with the peripharyngeal grooves (*p.p.*) which have now moved down ventrally and coalesced with it, the sloping lateral edges of the aperture of the endostyle into the branchial sac (Pl. IV. fig. 3).

The posterior end of the endostyle is found about section 220. Pl. IV. fig. 1, *en.*, shows its appearance in section 223 where it is composed of a mass of glandular cells lying half-way between the ventral surface of the branchial sac and the ectoderm, and having no connection with the pharynx. In section 225 (Pl. IV. fig. 2) the endostyle is larger and has a central lumen around which the glandular cells are placed; it has now nearly come into connection with the deep hypopharyngeal groove. In another couple of sections we find this connection established as is shown in section 228 (Pl. IV. fig. 3) where the endostyle has a considerable cavity opening by a narrow slit into the ventral part of the pharynx. The glandular cells are not equally developed around the whole wall of the endostyle but are arranged in four definite longitudinal tracts. After

a few sections the endostyle becomes again shut off from the pharynx, so that the opening between the two is very small and the greater part of the endostyle is not a canal as in most Tunicata, but a closed in tube (compare Pl. IV. fig. 9, *en.*). Its close resemblance both in transverse (Pl. IV. fig 3) and in longitudinal (fig. 9) section to its homologue the thyroid involution in the larval lamprey is more marked in this form, I think, than in any Tunicate yet figured. This endostyle differs considerably from that of *Vexillaria speciosa* as figured by Eisen.

Twenty sections further forward (Pl. IV. fig 4) we find the body greatly reduced in size, as we are now not far from the anterior end; while the tail is still very large. The branchial sac or pharynx is small and is transversely elongated. Above it we find the nervous system now becoming of considerable size, and ventrally is the closed endostyle composed of large glandular cells arranged below a small circular lumen. Six sections further forward (Pl. IV. fig. 5) we find the body and the branchial sac still smaller, the endostyle large but with no lumen now, and the nervous system larger than before with the otocyst attached to it, on the left side. On each side of the branchial sac is seen a large glandular mass which is the posterior end of an elongated cylindrical or sausage shaped closed gland lying at the side of the mouth (Pl. IV. fig. 5).

This section shows also the very large ciliated infundibulum (fig. 5, *d.t.*) which opens into the dorsal edge of the branchial sac, on the right side, and which probably corresponds to the opening of the hypophysial duct on the dorsal tubercle of an Ascidian. A few sections further forward, in No. 257, we see this organ still better, and the middle portion of this section is shown more highly magnified ($\times 600$) in Pl. IV. fig. 6. The pharynx is thin walled and irregular in shape with the ciliated funnel opening into the

right hand end of its dorsal surface. The cells near the aperture of the funnel are very large and distinct while the cilia they bear are long and numerous and lie directed upwards towards the inner end of the funnel. That cæcal end is supplied by a nerve. The central nervous system is here at its largest. It shows large granular nerve cells, and the otocyst (Pl. IV. fig. 6, *o.c.*). The endostyle and the lateral oral glands are very much as before.

Ten sections further forward, No. 266 (Pl. IV. fig. 7) we find the body still smaller. It is now close to the anterior end, and this is the last section we figure. The pharynx is now small and will shortly terminate in the oral aperture. The two large glands lie alongside it, but the endostyle is no longer visible ventrally, we are in front of its anterior end. Dorsally the nervous system is seen attached to the inner surface of the ectoderm, where it extends outwards into two lateral processes. Figure 8 shows this region more highly magnified (× 600). The ectoderm is here distinctly two layers thick, and is covered by a cuticle or test which can be traced as a distinct though thin layer completely round the body in this region.

The nervous system, then, when traced through the whole series of sections is seen to be connected anteriorly with the dorsal ectoderm close to the mouth; then it becomes free from the ectoderm and expands to form the large ganglionic mass or brain placed above the front of the pharynx (see Pl. IV. fig. 9, *n.s.*) and having two sense organs, the ciliated funnel and the otocyst, connected with it. The ganglion then tapers posteriorly to form a slender nerve cord, the myelon, which runs backwards over the pharynx, rather on the right side of the medio-dorsal line (Pl. III. fig. 3), until it reaches the œsophagus where it turns ventrally and runs down between the pyloric sac

and the right lateral lobe of the testis until it reaches the ventral surface between the stomach and the anterior end of the ovary (Pl. I. fig. 9). It now turns forwards, reaches the base of the tail, enlarges to form the caudal ganglion, and then continues onwards through the length of the tail lying on the left side of the notochord.

I have not discussed specially those detailed points in which the preceding account differs from those of Fol, Eisen and other authors. The new method of investigation, serial sections in place of transparent objects, might be naturally expected to yield some new results in matters of detail: besides I cannot be certain that my form is specifically identical with any of those previously described. I may mention, however, as perhaps the most interesting points shown in my figures:—the condition of the endostyle as a diverticulum to a great extent shut off from the branchial sac, the presence of a genital duct, the distribution of the enlarged ectoderm cells and the cuticular test, the exact course of the nerve cord through the posterior part of the body, and finally the shapes and relative positions of the alimentary and reproductive viscera.

Explanation of the Plates.

All the figures with the exception of fig. 9 on Pl. IV. were drawn from the sections, which were placed so that right and left sides of the figure represent right and left sides of the animal. With the exceptions of figs. 4, 5, and 8 on Pl. I. figs. 9 and 10 on Pl. III. and figs. 6 and 8 on Pl. IV. which show more highly magnified details, all the figures were drawn under a moderate magnification, about 115 diameters. The following abbreviations are used:—

a. anus, *app.* appendage or tail, *d.t.* dorsal ciliated funnel, *ec.* ectoderm, *ep.p.* epipharyngeal ciliated groove, *en.* endostyle, *gl.* glandular cells in left side (cardiac sac) of stomach, *h.* heart, *hy.p.* hypopharyngeal ciliated ridge or groove, *i.* intestine, *m.* mouth, *mes.* connective tissue, *n.* caudal nerve (posterior part of myelon), *n.ch.* notochord (urochord). *n.s.* nervous system (cerebral ganglion and anterior part of myelon, *œs.* œsophagus, *ov.* ovary, *o.g.* oral glands, *o.c.* otocyst, *o.d.* oviduct, *ph.* pharynx, (branchial sac), *p.p.* peripharyngeal ciliated bands, *r.* rectum, *st.* pyloric sac of stomach, *st'.* cardiac sac, *sp.* lobes of testis, *t.* test, *sg.* stigma leading to atrial pore.

Plate I.

Fig. 1. Section 8 (from posterior end) showing ovary and lobes of testis.

Fig. 2. Section 22, showing separation off of dorsal lobe of ovary.

Fig. 3. Section 35, immediately behind the alimentary canal.

Fig. 4. Small part of ovary from last section more highly magnified (× 600).

Fig. 5. Small part of testis from last section highly magnified (× 600).

Fig. 6. Section 48, showing posterior end of stomach.

Fig. 7. Section 54, showing stomach and œsophagus.

Fig. 8. A part of surface of section 54 more highly magnified (× 600).

Fig. 9. Section 61, showing parts of alimentary canal, and nerves.

Fig. 10. Section 71, showing œsophagus opening into stomach.

Plate II.

Fig. 1. Section 81, showing cardiac and pyloric sacs of stomach, &c.
Fig. 2. Section 95, showing junction of lobes of testis.
Fig. 3. Section 103, showing intestine leaving stomach.
Fig. 4. Section 113, showing diverticulum of rectum, &c.
Fig. 5. Section 125, showing branchial sac, heart, &c.
Fig. 6. Section 134, } showing the narrow opening of the
Fig. 7. Section 151, } intestine into the rectum.

Plate III.

Fig. 1. Section 155, showing the beginning of the tail.
Fig. 2. Section, 163, showing the anterior end of the stomach,
Fig. 3. Section 165, }
Fig. 4. Section 167, } showing the structure of the stig-
Fig. 5. Section 169, } mata.
Fig, 6. Section 183, }
Fig. 7. Section 190, showing the branchial sac in front of the stigmata.
Fig. 8. Section 216, showing the large lateral ectoderm cells.
Fig. 9. Part of tail from last section more highly magnified (× 600).
Fig. 10. Ectoderm cells from about section 200, highly magnified.

Plate IV.

Fig. 1. Section 223, }
Fig. 2. Section 225, } showing the relation of the endo-
Fig. 3. Section 228, } style to the branchial sac.
Fig. 4. Section 248, showing anterior cæcal part of endostyle, &c.

Fig. 5. Section 254, nervous system, sense organs, &c.

Fig. 6. Section 257, part of the centre, showing nervous system, &c., highly magnified (× 600).

Fig. 7. Section 266, showing anterior end of nervous system, oral glands, &c.

Fig. 8. Dorsal part of last section more highly magnified (× 600).

Fig. 9. Diagrammatic reconstruction of the animal from the sections, seen from the right hand side, showing the extent of the thickened ectoderm and test dorsally and ventrally, the course of the nerve cord, and the shapes, sizes and relative positions of the other organs, about 60 times natural size.

Post-script.—March 1;—Mr. W. Garstang, who was present when this paper was read, has kindly written to me since stating that in some sections of *Oikopleura* (? *dioica*) which he has made the endostyle is an open canal in the greater part of its extent. On the other hand Dr. Bousfield has very kindly sent me three additional series of sections of the same species of *Oikopleura* as before (? *flabellum*), and in these I find as in the one described above that the cavity of the endostyle is shut off from the pharynx above for more than half of its length. The actual numbers of sections involved in these new series are :—

I.	closed posterior	7	sects., open	14,	closed anterior	12.
II.	,,	6	,,	14,	,,	11.
III.	,,	10	,,	18,	,,	19.

AN ATTEMPT to ELUCIDATE the REAL STRUCTURE and RELATIONS of MOSS'S POLYSTIGMATIC APPENDICULARIAN.

By Walter Garstang, M.A.,
Jesus College, Oxford; Berkeley Fellow of the Owens College, Manchester.

With Plate V.

[Read March 11th, 1892.]

The Appendicularian, the account of whose structure has so often interested and puzzled the student of the Tunicata, was described in 1871 by its discoverer, Assistant-Surgeon E. L. Moss, R.N., in words which will be quoted shortly. In 1888 Professor Herdman* gave it the name *Appendicularia Mossi*; in his recent "Revised Classification of the Tunicata," † however, he has renamed it *Mossia dolioloides*. I agree with Professor Herdman in his removal of the species from the genus *Appendicularia*, but I shall endeavour to shew that no new genus is necessary for its reception, as it appears to find its true place within a generic group already established. Still I shall find it convenient, in the earlier part of my remarks, to refer to it under the distinctive name *Mossia*.

The following is the original description of *Mossia* given in Moss's paper:—‡

"I have lately captured a new short-bodied form, in the warm surface-water of the Atlantic, near the Line, and

* Report on the Tunicata of H.M.S. "Challenger," 3rd part, vol. xxvii, p. 124.

† Linn. Soc. Journ., xxiii, 1891, p. 650.

‡ On the Anatomy of the genus *Appendicularia*, with the description of a new form. Trans. Linn. Soc., xxvii, 1871, pp. 299—304, Pl. xlvii.

occasionally as far north as off the coast of Portugal. It can be distinguished at first glance from any of its Appendiculate brethren by the peculiar scroll-like manner in which its slender lanceolate flabellum is rolled upon itself when the animal is at rest. When examined under a magnifying power of about 100 diameters, the internal œconomy of this form is seen to differ widely, as regards its respiratory arrangements, from any of the known species. The oval [*sic*; oral?] half of the globular body contains a large branchial sac, with a ganglion and otolithe in the usual positions in its anterior paries, but with its posterior lining-membrane folded into a gill-like structure, wide in the centre and tapering to either end, extending from the posterior lip of the branchial orifice to a point close to the insertion of the appendix, and presenting a double series of narrow transverse slits, which give the whole structure a general resemblance to the respiratory diaphragm of *Doliolum*, though on a lengthened and much more minute scale. The last curve of the intestine lies transversely across the centre of the body, above a globular ovary, and terminates on the right side in a papilla, through which the rectum opens. The main nervous trunk, descending from the ganglion, curving round the stomach, and entering the appendix, presents no distinctive peculiarities."

Naturally a form so remarkable as this description indicates has excited much interest, and has lent itself very conveniently for the purposes of phylogenetic speculation. Moss himself referred to it in a later paper* as a connecting link between the Appendicularians and *Doliolum*, and Professor Herdman, in the summary appended

* Notes on the genus *Doliolum*; Quart. Jour. Micr. Sci., xi. (N.S.) 1871, p. 405.

to his "Challenger" Report,† gives it an equally important place in his phylogenetic scheme. But with the increase of research, serious morphological difficulties have been seen to present themselves in the unique structure of the pharynx in this Appendicularian; so that, subsequently, Professor Herdman appears to have entertained doubts with regard to the accuracy of the original description, and in his "Revised Classification" *Mossia* is referred to merely within the limits of a footnote.

I have myself for some time held a theory in regard to the supposed peculiarities of Moss's Appendicularian, and, as increased experience has only tended to strengthen my view, I now venture to submit it to the notice of other zoologists.

When the structure of *Mossia*, as indicated in the original description and figure, is compared with that of the other short-bodied Appendicularians (species of *Oikopleura*, *Appendicularia*, *Megalocercus* and *Stegosoma*), it is found to be peculiar in the following respects:—

(1) The tail is very long, at least $5\frac{1}{2}$ times the length of the body, and at the same time slender and lanceolate; its lateral (morphologically dorsal and ventral) fin-like expansions are extremely small at the proximal end, and dilate very gradually, so that the tail does not attain its maximum breadth until a point some distance beyond the middle of its whole length. In all the above-mentioned Appendicularians, on the other hand, the tail is only about 3 or, at most, 4 times as long as the body, and reaches its greatest breadth at a point almost immediately posterior to the region of its attachment to the body.

(2) The mouth is a simple circular aperture without any projecting lips. In all the other forms under comparison, with the exception of *Appendicularia sicula* and

† Third part, vol. xxvii., 1888, pp. 124, 125, 127, 149, 150.

Stegosoma pellucidum, there is a well marked inferior lip, which projects considerably, as Moss himself has figured it (l.c. fig. 4).

(3) The rectum and anus are high up on the right side of the body. In most forms they are median and ventral; in *Appendicularia* alone the anus is slightly to the right of the mid-ventral line.

(4) Neither endostyle nor heart is indicated in Moss's figure, although on the same plate he shews these structures in his figures of other Appendicularians.

(5) The pharynx is described as possessing a ventral fold, provided on each side with a longitudinal series of transverse stigmata, largest in the middle and becoming gradually smaller towards each extremity.

(6) No external branchial (atrial) apertures on the sides of the body are mentioned or figured (see Plate V. fig. 1).

It will be noticed that several of the peculiarities given in the above list are not to be found in the original description, which is characteristically short. They are derived, however, from a careful and critical examination of Moss's figure; and so exact are his representations of *Fritillaria* and *Oikopleura* on the same plate, that they furnish us with an ample guarantee as to the general accuracy of the figure which more especially concerns us.

It is usual to regard *Mossia* as noteworthy merely because of the rows of pharyngeal stigmata which it is said to possess; but the peculiarities which have just been mentioned are alone sufficient to distinguish it greatly from all the species of normal short-bodied Appendicularians. The conformation and length of the tail, the shape of the mouth and the position of the rectum and anus are without parallel in those genera; as is also, I may add, the apparent absence of heart and endostyle. Now these

are just those points which furnish an important clue to the real structure and affinities of the animal.

In Fol's beautiful and invaluable "Etudes sur les Appendiculaires du Détroit de Messine (1872)" we find a detailed description, together with good figures, of an aberrant Appendicularian, *Kowalevskia tenuis*, in which these four peculiarities again present themselves. *Kowalevskia tenuis* possesses, equally with *Mossia*, a truncated buccal extremity, "sans appendices ni protubérances," and a tail of considerable length, "lanceolée et pointu en arrière," of which, moreover, "la partie antérieure est étroite et va en s'élargissant très-lentement du point d' insertion jusqu' au maximum de largeur," which, as in *Mossia*, is to be found "à son tiers postérieur." The anus is not easy to see in *Kowalevskia tenuis*, but Fol made out that, upon slight pressure, the fæces always escaped at one point "au côté droit du corps, à la partie droite et ventrale du rectum. En sorte que l'existence, en cet endroit, d'un anus très-contractile est plus que probable." After careful search, Fol arrived also at the conclusion that heart and endostyle are entirely absent in his species (see Plate V. figs. 2 and 3).

Thus there is seen to be a strong *prima facie* case for the generic identity of these two peculiar forms of Appendicularians. There remains, however, the consideration of two apparent discrepancies in regard to the structure of the pharynx and the presence of atrial apertures. To take the second first,—there is no attempt in Moss's figure to represent the external apertures of the two branchial (atrial) canals which exist in all other forms. Either they do not exist as such, and the supposed stigmata lead directly to the exterior; or they have been overlooked. The former alternative cannot easily be reconciled with Moss's description. For he expressly states that the

stigmata are present, not in the lateral walls of the pharynx,—in which case they might lead directly to the exterior, but in a *fold* of the ventral wall,—an arrangement obviously opposed to any direct communication with the exterior. Moreover, he states that the presence of the stigmata in the pharyngeal wall of *Mossia* gives the whole structure a general resemblance to the respiratory diaphragm of *Doliolum*; and, since the stigmata in the so-called diaphragm of *Doliolum* connect the pharyngeal with the cloacal cavity, it is clear that Moss believed that the "stigmata" in his species were also openings from the pharynx into a water-space around it. That they are not openings into a true cloaca, like that of *Doliolum*, is manifest from the fact that the intestine in *Mossia* opens directly to the exterior. We are therefore bound to infer that the stigmata, if really present, lead into a pair of exhalent or atrial canals as they do in larval Ascidians. And if Moss was mistaken as to the presence of stigmata, there is still less reason for doubting the existence of structures homologous with the branchial canals of other Appendicularians. They must have been overlooked owing to some unusual and deceptive conformation.

Such a conformation is actually presented by *Kowalevskia tenuis* (fig. 3, AW). In this species the exhalent canals are not long and tubular as they are in the greater number of Appendicularians; they are hardly anything else than large apertures in the sides of the pharyngeal region of the body: their diameter is enormous, and their length (from pharynx to body-wall) is reduced to a minimum. If we bear in mind that—to quote Fol's words—"this little creature is of an extreme delicacy and transparency," and that Surgeon Moss made his observations under the "peculiar difficulties of study at sea," we can not greatly wonder that he failed to notice spaces so large

and at the same time so shallow as the branchial canals of a *Kowalevskia*. Even Huxley entirely overlooked their homologues in his earlier observations upon the anatomy of Appendicularia; while Gegenbaur, who first noticed them, described them as leading from the pharynx into the general cavity of the body.

The other and the chief discrepancy can also be accounted for, although the explanation to be offered involves the downfall of the character upon which the importance of *Mossia* has hitherto been chiefly based. The pharynx of *Kowalevskia tenuis* is provided with four longitudinal rows of ciliated digitiform processes, which project within its cavity. Two of these rows are for the most part dorso-lateral in position, but anteriorly they bend round the wall of the pharynx and are united with one another in the mid-ventral region just behind the mouth; the two remaining rows are ventro-lateral, and they are similarly connected with one another in the mid-ventral line anteriorly, at a spot close behind the junction of the dorso-lateral rows. All four rows converge posteriorly in the œsophageal region. The digitiform processes from these ciliated bands are longest in the middle and become gradually shorter towards each extremity. They project in such a way that the extremities of the dorsal processes almost meet the tips of the ventral ones of the same side; for the gradual approximation of the dorsal and ventral bands anteriorly and posteriorly compensates for the accompanying diminution in the length of the ciliated processes (fig. 3, DR, VR).

The gill-like fold of the ventral wall of the pharynx of *Mossia*, "wide in the centre and tapering to either end, extending from the posterior [i.e. ventral] lip of the branchial orifice to a point close to the insertion of the appendix [the tail]," is in my opinion nothing else than the expres-

sion of a pharyngeal apparatus similar to that of *Kowalevskia tenuis*, as seen under a comparatively low power of the microscope and imperfectly comprehended. The projection of the rows of close-set ciliated processes within the pharyngeal cavity has been described as a fold of the pharyngeal wall pierced by stigmata. The spaces incompletely bounded by the dorsal processes above and the ventral processes below could easily give rise to a belief in the existance of stigmata: Fol himself compares their appearance to that of two rakes with their prongs almost in contact, or to a sieve (*double râteau, tamis*, Fol, l.c., p. 41). By a curious coincidence, however, both Moss and Fol figure oblique views of their animals, a comparison of which inclines me to believe that the former mistook the ciliated processes themselves for stigmata (cf. Fol, Pl. X. fig. 5 with Moss, Pl. XLVII. fig. 5). The correspondence between these two figures is far too complete to be merely accidental, and it seems clear to me that Moss, examining his animal from the right side, mistook the dorsal row of processes for a row of stigmata on the left of the median line, while the ventral row of processes constitutes his row of stigmata on the right side. Upon this view, the elongated elliptical band, marked U in Moss's figure, is possibly the huge aperture of the right branchial canal (fig. 1, U; fig. 3, AW). Here again the mistake, which Surgeon Moss made, is not without parallel. Sanders* mistook a number of large ectoderm cells for stigmata in a species of *Oikopleura*, and described the animal as provided with a branchial canal on one side only—that of the other side having been overlooked!

*(1) Contributions towards a knowledge of the Appendicularia. Monthly Microsc. Journ., XI., 1874, p. 141.

(2) Supplementary Remarks on Appendicularia. Monthly Microsc. Journ., XII., p. 209.

The above considerations have led me to conclude that the Appendicularian described by Surgeon Moss has no special resemblance to *Doliolum*, but has a structure which is all but identical with that of *Kowalevskia tenuis*. The similarity between these two creatures in some of their most leading characteristics (shape of the tail and mouth, position of the anus) is very marked, and they apparently agree with regard to several other points (absence of heart and endostyle, shortness and extent of the branchial canals). This resemblance between the two forms is so complete that, if our knowledge were confined to these facts, the generic identity of *Mossia* and *K. tenuis* would be at once recognised. The only statement opposed to this conclusion is in itself improbable, and is based upon appearances which are capable of another interpretation. The explanation which has been suggested makes the connection of *Mossia* with other Appendicularians quite clear, and, if it be accepted, the structure and relationship of this form will no longer remain a mystery.

Beyond this point, however, we cannot justly go. These two animals may be considered as members of the same genus, but it is advisable, for the present at any rate, to regard them as specifically distinct, on the ground of the following minor differences.—Firstly, Fol states the length of the tail and body in *Kowalevskia tenuis* to be respectively 8 and 1.1 mm.,—that is, in a proportion of 7.27 : 1 ; while a careful calculation of the length of the same parts in Moss's species, as determined from his figure and scale, gives a length of from 3.556 to 3.685 mm. for the tail and of 0.635 mm. for the body,—a ratio of only from 5.6 to 5.8 : 1, and this ratio would possibly have become still smaller when the specimen drawn by Moss had become fully mature, and its body distended with genital products. Secondly, the caudal muscle-bands of *K. tenuis* are narrower

and for the most part considerably narrower, than twice the diameter of the notochord; while in Moss's individual the muscle-bands are drawn three times the width of the notochord almost along their whole length. Thirdly, in the former species the intestine is extremely short and the anus is inconspicuous; while in the latter species the intestine appears to be of more normal length and the rectum is said to open through a papilla. Fourthly, a characteristic habit has been described for each species, which is not the same in the two cases. *K. tenuis*, without changing its situation, gives every 3 or 4 seconds a stroke of its tail, which puts it in a position at right angles to its preceding position, so that after four strokes of its tail it has returned almost to its first position (Fol, l.c., p. 37); Moss's species, on the other hand, "can be recognised at a glance by the peculiar scroll-like manner in which its slender lanceolate flabellum is rolled upon itself when the animal is at rest." It is, of course, easily conceivable that these two habits might coexist in the same species; but it is extremely unlikely that the habit noticed by Moss would have escaped the keen eye of Fol, or would have been unmentioned by him, if it had occured in the species he described. The distribution is also seemingly different; *K. tenuis* has only been found in the Mediterranean, while Moss's species was met with in the Equatorial Atlantic, "and occasionally as far north as off the coast of Portugal."

The following diagnoses represent briefly the relations which I have endeavoured to establish between the two remarkable Appendicularians mentioned in this note:—

Genus KOWALEVSKIA, Fol, 1872 (*emend.* 1874).

Tunicata Perennichordata, consisting of a smooth ovoid body, truncated anteriorly, and a long lanceolate tail,

which is narrow at its attachment, enlarges very gradually and attains its greatest breadth near the commencement of the distal third of its length, after which it tapers gradually to terminate in a pointed extremity; mouth destitute of projecting lips; pharynx* devoid of a glandular endostyle, and provided with a large number of ciliated digitiform processes, arranged in two double rows, one pair obliquely dorsal, the other pair ventral, each pair being united anteriorly in the mid-ventral line of the pharynx; branchial canals (gill-slits) in the form of a pair of enormously dilated elliptical apertures in the ventro-lateral regions of the body; anus on the right side of the body; heart absent.

Kowalevskia tenuis, Fol, 1872.

Tail $7\frac{1}{4}$ times as long as the body.

Caudal muscle-bands narrower than twice the diameter of the notochord.

Intestine extremely short; *anus* highly contractile and inconspicuous.

Habits.—Movements slow and lacking energy; has a characteristic habit of slowly rotating itself, without changing its situation, by giving every 3 or 4 seconds a stroke of the tail, which puts the animal in a position at right angles to its previous position. Forms a large gelatinous "Haus" of peculiarly simple dome-like shape.

Distribution.—Abundant at Messina from April to June, 1871, and met with again in 1873.

* I have purposely omitted Fol's statement concerning the absence of the peripharyngeal band, for I believe that the dorsal or anterior horse-shoe-shaped row of ciliated processes is the morphological equivalent of that structure; its limbs take a course which is identical with that assumed by the peripharyngeal band in *Oikop'eura cophocerca*.

Kowalevskia Mossi, Herdman (sp.) 1888.

Appendicularia n.sp., Moss, 1868.
Appendicularia Mossi, Herdman, 1888.
Mossia dolioloides, Herdman, 1891.

Tail $5\frac{3}{4}$ times as long as the body.

Caudal muscle-bands three times as wide as the diameter of the notochord.

Intestine (apparently) of normal length; *anus* situated on a papilla.

Habits.—When at rest, the tail is rolled upon itself in a characteristic scroll-like manner. Not known to form a "Haus."

Distribution.—Found in 1867-1868 in the warm surface-water of the Atlantic, near the Equator, and occasionally so far north as off the coast of Portugal.

Description of Plate V.

Fig. 1. *Kowalevskia Mossi*, Herdman. An exact copy of Moss's figure (Trans. Linn. Soc., vol. xxvii, Pl. 47, fig. 5), of which the following is the original explanation:—A, vascular canal of the appendix. B, muscular bands of the appendix. C, nervous cords of the appendix. D, central axis [notochord] of the appendix. G, branchial orifice. I, nervous branches surrounding the branchial orifice. K, otolithe and its sac. M, principal nervous trunk. Q, rectum. R, stomach [? intestine]. S, ovary.

In repeating Moss's explanation, I ought to add that this observer was undoubtedly wrong in attributing *two* nerve-cords to the tail of this Appendicularian. He made the same mistake with regard to *Oikopleura* and *Fritillaria*.

Fig. 2. *Kowalevskia tenuis*, Fol. An adult specimen, seen from the ventral side. Enlarged 15 times. (After Fol, l.c., Pl. XI. fig. 1).

Fig. 3. *Kowalevskia tenuis*, Fol. A specimen not quite adult, seen from the right side. Enlarged 100 times. (After Fol, l.c., Pl. X. fig. 5—the rudimentary "Haus," however, omitted.) The signification of the letters is the same in figures 2 and 3. A, atrial apertures (gill-clefts). A.W., walls of the right atrial aperture. C.V., ciliated vesicle. D.R., dorsal row of ciliated processes of the right side. L.D.R., dorsal row of ciliated processes of the left side. M, muscle-bands of the tail, extending a short distance beyond the notochord on each side. N, notochord of the tail. N.C., nerve-cord. O, ovary. O.A., oral aperture. Œ, œsophagus. Ot., otolith. P, processes by which the rectum is attached to the body-wall. R, rectum. The anus is situated within the area occupied by the dark mass in the rectum. S, stomach. T, testis. V.R., ventral row of ciliated processes of the right side.

Post-script.—In his just published "Notes on the Structure of *Oikopleura*" (Trans. L'pool Biol. Soc. vol. VI. p. 40), Prof. Herdman suggests that Moss may have mistaken large glandular cells of the endostyle for stigmata *à la* Sanders; but this theory would necessitate the existence of an endostyle of much greater length than is presented by any other Appendicularian.

NOTES on the Collections made during the Cruise of the S.Y. "ARGO" up the WEST COAST of NORWAY in July, 1891.

By W. A. Herdman, D.Sc., F.R.S.,
PROFESSOR OF NATURAL HISTORY IN UNIVERSITY COLLEGE, LIVERPOOL.

With Plates VI. and VII.

[Read 11th March, 1892.]

I have again to thank Mr. Alfred Holt for his kindness in giving me an opportunity of collecting marine animals by dredging and tow-netting from his steam yacht "The Argo." After our experiences of the previous summer off the Irish Coast (see Trans. Biol. Soc., vol. V., p. 181), Mr. Holt considered it advisable to use a much stronger steel-wire rope, so he laid in 800 fathoms of No. 5 wire guage, with a breaking strain of 2600 lbs., nearly one and a quarter tons. This rope measured $^3/_{16}$ inch in diameter, and consisted of 27 strands of wire round a central core. This proved sufficiently strong for our purpose, and everything worked so satisfactorily that we did not even lose a tow-net during the month's cruise, while the collections made were considerable, as the records which follow will show.

The apparatus taken consisted of the ordinary naturalists' dredges and trawls with hempen tangles, and tow-nets of various sizes. We had also a small tank of methylated spirits for the reception of large specimens, several cases of bottles, jars, and tubes, some small aquaria, microscopes, and the usual preserving and mounting re-agents and implements. Before starting I had made a small folding work table (see Pl. VII.) for use

on deck, which was found most convenient, and which I strongly recommend to those wishing to do any biological work at sea. When shut up it forms a shallow closed-in box measuring 2 ft. by 2 ft. by 4 in., which contains a travelling microscope, a couple of small dissecting trays, some pipettes and tubes, the ordinary mounting re-agents and dissecting instruments, &c., and can be conveniently carried like a hand bag by a handle on one side. When the legs are spread out and the lid folded back it is a steady table, with a raised edge all round (most important at sea to prevent things rolling off), and compartments for bottles, microscope, note-book, and so on. Two of these compartments are fitted to receive large collecting bottles, and there are corresponding holes in the lid above them, so that a tow-net gathering just taken, or any animals in a jar under observation, may be conveniently and safely left standing for a time in the table with the lid closed. It is never safe at sea to lay a collecting bottle down anywhere except in a receptacle which cannot be upset by a sudden roll of the ship. Figure 1 on plate VII shows this deck table opened out for work, while figure 2 represents it folded together for carrying.

The "Argo" left the Mersey about 3 a.m. on June 28th and reached the Kors Fjord, Norway, on the afternoon of July 1st. No dredging was done on the way; but on the afternoon of June 29th, when passing Applecross Bay, Scotland, although going at full speed it was noticed that the smooth surface of the sea had in places an appearance like the splashing of very fine rain, so the ship was stopped and a tow-net gathering taken. The net was found to contain a number of very large specimens of the Copepod *Calanus finmarchicus*, Gunner, along with a few of *Dias longiremis*, Lillj., and of *Pseudocalanus elongatus*, Boeck. The *Calani* although not so brightly coloured as

those we subsequently got in vast quantities off the North Coast of Norway were quite as large and were exceedingly active. The agitation of the smooth surface which we had seen may have been the result of their violent leaps, or possibly was caused by numbers of small fish fry pursuing and eating the Copepods.

Between July 1st, when we entered the Kors Fjord, and July 20th, when I had to leave the "Argo" at Bergen, we coasted along the West and North of Norway to Sværholtklubben (Porsanger Fjord), about 30 miles beyond the North Cape, and back again, dredging and tow-netting whenever opportunity permitted. During these twenty days we dredged in exactly 20 distinct localities lying between Kors Fjord (Bergen) and the North Cape, some of them up fjords, some in the open, and ranging in depth from 10 to nearly 400 fathoms; while we tow-netted on 26 occasions, generally on the surface, in the day, occasionally at or near the bottom (in no great depth), and sometimes at night. After I left, Miss Holt very kindly continued to take tow-net gatherings for me at the various places in the Sogne and Hardanger fjords where the ship stopped, and so brought back 10 additional bottles of "plankton," in two of which Mr. Thompson found the specimens of the new Rotifer *Anuræa cruciformis* (see p. 77). These 36 bottles of tow-nettings have been carefully examined by Mr. I. C. Thompson, F.L.S., and he has supplied me with detailed statements of the contents, from which the records which follow are compiled. Before giving the lists of localities, and of species, it may be remarked that among the more noteworthy forms obtained in the tow-net were:—*Anuræa cruciformis*, n.sp., *Temorella affinis*, *Dias intermedius*, *Pontella wollastoni*, *Stenhelia hispida*, *Thalestris helgolandica*, *T. peltata*, and *Scutellidium fasciatum*.

The dates and localities of the tow-nettings are as follows. The most abundant and characteristic forms taken are added in brackets: for a full list see p. 76.

1. June 29, afternoon, off Applecross Bay, Scotland.
2. July 1, in outer part of Kors Fj., near Sund. (Copepoda and *Ceratium*).
3. July 1, in inner part of Kors Fj., near Leere-Osen.
4. July 1, all night, and July 2 all day, net out while at anchor at Bergen. (*Ceratium*, sev. sp.)
5. July 2, evening, off Ask, 4 miles north of Bergen.
6. July 2, night, net out while anchored at Napsvaag, near Fens Fj. (poor).
7. July 3, mid-day, middle of Stav Fj. (2 nets) (*Ceratium*, *Evadne*).
8. July 3, afternoon, net out while anchored at Florö, north of Stav Fj. (*Ceratium* and Fish Ova).
9. July 3, net out all night, while anchored at Moldoen, Nord Fj. (*Ceratium*, sev. sp.).
10. July 4, Mid-day, off Tysvik, Storfj. (*Ceratium* and *Evadne*).
11. July 4, all night, also July 5, forenoon, while anchored at Hellesylt, Sunelvs Fj. (*Ceratium*, *Podon*, *Centropages*).
12. July 6, noon, off Aarlotnes, Throndhjem Fj. (*Certium* and Copepoda).

12A. July 6, evening, in harbour of Throndhjem from small boat, also net out all night. (*Ceratium*, *Evadne*, Copepoda, 7 sp.).

12B. July 7, morning, off Throndhjem. (*Ceratium*).

13. July 7—8, 10 p.m. to 4 a.m., Stoksund, north of Throndhjem. (*Evadne* and Copepoda).
14. July 8, afternoon, off Torghatten, Nordland. (*Evadne* and *Podon*).
15. July 10, all night, while anchored at Havösund

between Hammerfest and North Cape, 2 surface nets and a bottom one (14 fms.) (*Calanus*).

16. July 12, 5 a.m. to 11.30, while anchored at Hammerfest, both surface and bottom. (*Calanus*).
17. July 12, afternoon, off Sildmylingen at west end of Sorösund.
18. July 12, 11.40 to midnight, at entrance of Lyngen Fj. (*Calanus*).
19. July 13, all day, anchored at Tromsö. (*Calanus*, *Harpacticus*).
20. July 15, afternoon, in Lekoë Fj. (*Ceratium*, sev. sp.).
21. July 16, all day, anchored in outer harbour at Throndhjem. (*Ceratium*, Diatoms, *Evadne*, Copepoda).
22. July 17—18, all night, anchored at Næs, Romsdals Fj. (*Ceratium*, *Podon*, Copepoda, 6 sp.).
23. July 18, afternoon, anchored at Aalesund. (*Ceratium*, *Oithona*).

23A. July 19, 3 a.m. to noon, Moldoen. (*Ceratium*).

24. July 19—20, evening and all night, Napsvaag, Fens Fj. (*Ceratium* sev. sp., Copepoda 17 sp.).
25. July 21, 10 p.m., to July 22, 3 p.m., Fjaerland, Sogne Fj. (*Ceratium*, *Evadne*).
26. July 22, 5 p.m., to July 23, 7 a.m., Balholm, Sogne Fj. (*Ceratium*, *Temora*).
27. July 23, 8 p.m., to July 24, 6 p.m., Laerdalsören, Sogne Fj. (*Evadne*, *Tachidius*).
28. July 24, 10 p.m., to July 25, 6 p.m., Gudvangen, Sogne Fj. (*Ceratium*, *Evadne*, *Temorella*).
29. July 25, 10 p.m., to July 26, 9 a.m., Balholm, Sogne Fj. (Poor).
30. July 27, 8 p.m., to July 28, 7.30 a.m., Lervik, Hardanger Fj. (Copepoda, 12 sp.).
31. July 28, 10 a.m. to 2 p.m., Haugesund. (Copepoda).

32. July 28, 7 p.m., to July 29, 9 a.m., Stavanger. (*Tintinnus*, Copepoda, 9 sp.).
33. July 29, 8 p.m., to July 30, 7 a.m., Saude, Bukken Fj. (*Anuræa*, *Ceratium*, Copepoda).
34. July 30, 10 a.m. to 12.30 p.m., Hylen, Bukken Fj. (*Anuræa*).

We may take as one of the more varied gatherings, No. 24, evening of July 19, at Napsvaag, which contained :—

Ceratium tripos, Müll. .....abundant
C. fusus, Ehr..... do.
C. furca, Ehr..... do.
Tintinnus denticulatus, Ehr. .....several
Medusoids (small) .....few
Zoea and Megalopa stages .....few
Centropages hamatus, Lillj .....several
C. typicus, Kr..... do.
Dias longiremis, Lillj ..... do.
Oithona spinifrons, Boeck..... do.
Thorella brunnea, Boeck .....few
Harpacticus chelifer, Müll. .....do.
Scutellidium tisboides, Claus. .. ..do.
S. fasciatum, Boeck.....do.
Cyclopina gracilis, Claus .....do.
Laophonte thoracica, Boeck.....do.
Dactylopus tisboides, Claus .....do.
D. strömii, Baird .....do.
D. similis, Claus.....do.
Stenhelia hispida, Brady .....do.
Ectinosoma atlanticum, Br. and Rob....several
E. spinipes, Brady .....few
Idya furcata, Baird .....do.

Mr. Thompson has drawn up for me the following list of all the species which he has identified from the tow-

nettings. The numbers in brackets show the localities (as in preceding list, p. 73) where each species occurred.

Ceratium tripos, Müll. (2, 4, 5, 8, 9, 10, 11, 12, 12A, 12B, 20, 22, 23, 23A, 24, 25, 26, 28, 31, 33).

C. fusus, Ehr, (9, 20, 21, 24).

C. furca, Ehr. (9, 12B, 20, 23, 24).

Tintinnus denticulatus, Ehr. (2, 9, 12, 24, 30, 31, 32).

T. campanula, Ehr. (9, 12, 20, 23, 24, 26, 29).

Evadne nordmanni, Lov. (2, 4, 7, 9, 10, 11, 12, 12A, 13, 14, 20, 21, 23, 25, 26, 27, 28, 29, 31, 32).

Podon intermedium, Lillj. (11, 14, 20, 21, 22, 23A, 26, 27, 28, 29, 30, 32, 33).

Calanus finmarchicus, Gün. (1, 2, 10, 15, 16, 18, 19, 22, 30, 32).

Pseudocalanus elongatus Boeck. (1, 9, 22, 31, 32).

Temora longicornis, Müller (7, 12, 12A, 12B, 20, 22, 25, 26, 27, 31, 32, 33).

Temorella affinis, Poppe (26, 28, 30, 32, 33).

Centropages hamatus, Lillj. (2, 11, 12, 12A, 12B, 20, 22, 24).

C. typicus, Kr. (24).

Diaptomus richardii, Sch. (12A).

Dias longiremis, Lillj. (1, 2, 10, 12, 12A, 12B, 13, 14, 20, 21, 24, 30, 33).

D. intermedius, Poppe (25).

D. discordatus, Gies. (32).

Thorellia brunnea, Boeck (24).

Pontella wollastoni, Lubb. (30).

Oithona spinifrons, Boeck (2, 7, 11, 12, 12A, 12B, 14, 19, 20, 21, 22, 23, 23A, 24, 30, 31, 32).

Cyclops tricuspidatus, Claus (12A).

Cyclopina gracilis, Claus (9, 24).

C. littoralis, Brady (12).

Longipedia coronata, Claus (13)

Ectinosoma atlanticum B. & R. (11, 12A, 20, 22, 23, 23A, 24, 30, 31, 32, 33).
E. spinipes, Brady (25, 33).
Tachidius brevicornis, Müll. (27, 28).
Stenhelia hispida, Brady (24).
Canthocamptus palustris, Brady (26).
Laophonte thoracica, Boeck (24).
L. similis, Claus (30).
Dactylopus tisboides, Claus (2, 23, 24, 25, 30, 31).
D. similis, Claus (24).
D. strömii, Baird (13, 24).
Thalestris helgolandica, Claus (30, 33).
T. rufocincta, Norman (30).
T. hibernica, B. & R. (30, 33).
T. peltata, Boeck, (31).
Harpacticus chelifer, Müll. (7, 9, 19, 24, 30, 31).
H. flavus, B. & R. (25).
Alteutha depressa, Baird (13).
Idya furcata, Baird (20, 21, 24, 31).
Scutellidium tisboides, Claus (24).
S. fasciatum, Boeck (24).
Anuræa cruciformis, n.sp. (33, 34).
Amphipoda, Isopoda, and Schizopoda (1, 11, 12A, 13, 18, 19, 25, 26, 34).
Appendiculariidæ (31).

The new species of Rotifer taken at two localities (33, 34) in the Bukken Fjord was submitted to Dr. Hudson, who concurred in the opinion that it was an undescribed species. Mr. Thompson gives the following diagnosis:—

Anuræa cruciformis, n.sp.

> Lorica subovate, tessellated so as to show a cruciform marking, armed with six occipital spines; no spines behind. The tessellation is formed by one central longitudinal line crossed by two transverse

lines dividing the lorica into six nearly equal portions. The spines are all of about the same length, generally straight and pointed, each pair united by a raised edge continuous with the lorica. Eye not conspicuous in the preserved specimens. Mastax well developed.

Before leaving this subject of surface life I may record here what was noticed at the time in a letter to "Nature" (for July 23rd, 1891, p. 273, "Copepoda as an article of food"), viz., that we tried the experiment of cooking and eating a gathering of "plankton." While tow-netting in the neighbourhood of the North Cape we had had some large hauls of Copepoda, and it occurred to us, on the night of July 12th, while watching the midnight sun off the entrance to the Lyngen Fjord, that one gathering might be spared from the preserving bottle and devoted to the saucepan. Accordingly we put out one of the smaller tow-nets (3½ feet long, mouth 1 foot in diameter) from 11.40 p.m. to midnight, the ship going dead slow, and traversing in all, say, a mile and a half during the 20 minutes. The net when hauled in contained about three heaped up table-spoonfuls of the large red Copepod *Calanus finmarchicus*. We conveyed our material at once to the galley, washed it in a fine colander, boiled it for a few minutes with butter, salt and pepper, poured it into a flat dish, covered it with a thin layer of melted butter, set it in ice to cool and stiffen, and had it next morning for breakfast, when we found it most excellent. The taste was less pronounced than that of shrimps, and had, we though, more the flavour of lobster. Our 20 minutes haul of the small net through a mile or two of sea made, when cooked in butter, a dishful which was shared by eight people, and would probably have formed with ship biscuits or bread a nourishing meal for one person. It would apparently, in these northern seas at least, be an easy matter to gather

very large quantities of Copepoda which might be preserved in tins or dishes like potted shrimps.

Turning now to the collections obtained from the sea bottom by means of the dredge, I have to acknowledge the kind assistance of the following friends, all members of the Biological Society, in separating out the groups and identifying a number of the species. Dr. G. W. Chaster, of Southport, has examined and named the Foraminifera, Dr. R. Hanitsch the Sponges, Miss L. R. Thornely the Zoophytes and Polyzoa, Miss L. Buckley, B.Sc., some of the Alcyonaria and Echinodermata, Mr. A. O. Walker the Crustacea and Pycnogonida, and Miss J. H. Willmer a number of the Tunicata; while the late Mr. Francis Archer shortly before his sad death went over most of the Mollusca and Brachiopoda with me, and I have gratefully made use of the notes which he left. The collections of several of the groups are extensive, and require such detailed examination at the hands of specialists, that the results cannot be given for some time. Dr. Hanitsch will report at length upon the Sponges in a separate paper, and the Vermes and most of the Actinozoa still await investigation.

I shall give first a list of the localities where we dredged, with particulars, and a record of the animals, so far as they are yet known, obtained on each occasion. Finally will be found a brief account of those groups which have been worked up and which require some special mention.

The stations where we dredged (see Plate VI, I to XX) were as follows:—

I. July 1. Kors Fjord, near Leere-osen, 89 fms.; dredge half full of mud and stones.

Phakellia ventilabrum, *Thenia* sp., a slender

Calcareous sponge, and a thin incrusting purple Ceratose sponge.

Virgularia (?) sp.

Rhabdopleura mirabilis, on stones.

Terebratula cranium.

Holothuria intestinalis, and some Ophiuroids.

Aphrodite sp., and various worm tubes.

Ægа ventrosa, *Pandalus brevirostris*, *Galathodes tridentata*, and *Munida bamffica*. In the last Mr. Walker says the ciliated eyes and 3rd maxillipedes agree with *M. bamffica*, but the slender hands are like *M. tenuimana*.

Pecten aratus, *Astarte sulcata*, *Scalaria* sp., and *Aporrhais pes-pelicani.*

II. July 2. Off Ask, 4 miles from Bergen, 200 fms.

Tethya lyncurium.

Holothuria intestinalis, *Synapta* sp., *Psolus phantapus.*

Flustra sp., and some Polychæta.

Crania anomala (on large stone).

Galathodes tridentata, *Eupagurus cuanensis*, and *Hyas coarctatus.*

Styela sp.

III. July 3. Stav Fjord, near middle, 200 fms., mud.

Sponges (3 species of Monaxonids.)

Actinians.

Aphrodite, and many worm tubes.

Stichopus natans.

Crania anomala and *Terebratula caput-serpentis.*

Lima excavata, *Ostrea edulis*, *Thracia papyracea*, *Chiton* sp., *Dentalium entale*, *Acmæa testudinalis*, *Littorina littorea*, *Natica clausa*, *Margarita* sp., *Trophon clathratus*, *Aporrhais pes-pelicani.*

Didemnum sp.

IV. July 3. Near Florö, dredging from ship's boat, 20—40 fms.

Acanthella sp.

Stichaster roseus, Echinus miliaris, Chirodota sp.

Pycnogonids.

Crania anomala and *Terebratula caput-serpentis.*

Axinus flexuosus, Chiton sp., *Margarita* sp., *Lacuna* sp.

V. July 4. Stor Fjord, off Tysvik, 250 fms., mud.

Kophobelemnon sp.

Stichopus natans.

VI. July 6. Throndhjem Fjord, outer part. Began in middle of fjord, 300 fms., soft bottom; at end dredged towards rocky promontory on north side near Aarlotnes, and then hauled up in shallow water. Dredge evidently came up face of cliff, and caught frequently, finally struck fast, then after a great strain the dredging boom broke and dredge came up uninjured with net full.

Phakellia ventilabrum, Oceanapia sp., *Iophon* sp.

Alcyonaria, various, including *Clavularia arctica.*

Lophohelia prolifera.

Stylaster sp., and some other Hydroids.

Retepora cellulosa, and 7 other species of Polyzoa.

Astrophyton linckii, Astropecten sp., *Antedon* sp.

Brissus sp., *Stichopus natans*, and various ophiuroids.

Filograna implexa, Serpula sp., and other worm tubes.

Terebratula caput-serpentis.

Scalpellum strömii, Galathea sp.

Chordylochela longicollis, Nymphon strömii, N. macrum, Chaetonymphon spinosum.

Lima excavata, Anomia ephippium, Saxicava

rugosa and var. *arctica*, *Astarte sulcata*, *Arca pectunculoides* var. *septentrionale*, *Leda pernula*, *Pecten abyssorum*, *Modiola* sp., *Syndosmya alba*, *Dentalium entale*, *Emarginula crassa*, *Natica clausa*, *Puncturella noachina*, *Trophon clathratus*, *Cerithium reticulatum*, *Aclis* sp., *Eulima subulata (?)*, *Rissoa parva*, and *R. abyssicola*.

Ascidia sp. and Compound Ascidians.

VII. July 10. Havösund, 25 miles from North Cape, 10 to 14 fms.; dredged while at anchor by taking out dredge in small boat and dropping it a couple of hundred yards from ship and then hauling in slowly—bottom *Melobesia* and brown algæ.

Strongylocentrotus drobachiensis, *Synapta* sp., and Ophiurids, Polychæta, various.

Hyas araneus, *Sabinea septemcarinata*, *Pandalus annulicornis*, *Buccinum undatum*, *Lacuna* sp.

VIII. July 11. Halfway from Havö to Maasö, 50 fms., a varied haul.

Polymastia sp., *Erylus* sp., *Myxilla* sp. and *Craniella cranium*, *Sertularia abietina*, *Coryne* sp., *Eudendrium* sp., *Coppinia arcta*.

Cucumaria frondosa, some Asterids and Ophiurids.

Retepora cellulosa, and 22 other species of Polyzoa. *Terebratula cranium*.

Hippolyte spinus, *Eupagurus cuanensis*, *Inachus dorsettensis*.

Ascidia obliqua, *Cynthia echinata*, *Amaroucium*, *Molgula*, *Microcosmus*, *Distoma*.

IX. July 11. Two and a half miles East of Sortvigen on Hjelmsö, 75 fms. Dredge nearly full of Simple Ascidians.

Craniella sp.

Rhabdocynthia pyriformis, Styela rustica, and *St. monoceros* (very many), *Amaroucium.*

X. July 11. West by North of North Cape, 11 miles off, 150 fms.; gravel. Haul consisted chiefly of Brachiopoda.

Actinians.

Ophiurids, sev. species.

Retepora cellulosa and other Polyzoa.

Terebratula cranium, (very many).

Serpula and other worm tubes.

Scalpellum sp., Amphipods, *Galathea nexa, Nymphon* sp.

Ciona intestinalis, Styela rustica, Goodsiria sp.

XI. July 12. Off Sildmylingen, West end of Sorösund, 350 fms., stiff mud. Only a few Gephyrea and some worm tubes could be washed out of the mud.

XII. July 13. Tromsösund, 70 fms.

Ascetta sp.

Actiniarians (large, on *Neptunea despecta*).

Thyone raphanus, and various Ophiurids.

Onuphis conchilega and other worms and tubes.

Palæmon fabricii, Hippolyte spinus, Sabinea septemcarinata, Eupagurus cuanensis, Pycnogonum littorale.

Rhynconella psittacea.

Ascidia sp. and Compound Ascidians.

Pecten islandicus, Venus fasciata, Astarte sulcata and *A. compressa, Leda pernula, Saxicava rugosa, Modiolaria* sp., *Chiton* sp., *Dentalium entale, Margarita* sp., *Trochus cinerarius, Scalaria groenlandica, Velutina lævigata, Buccinum undatum, Neptunea despecta* var. *carinata, Turritella communis, Philine* sp.,

Scaphander lignarius, Lepeta cæca, Trichotropis borealis, Natica clausa, Trophon clathratus var. *gunneri, Pleurotoma rufa* and *P. pyramidalis. Doris* sp.

XIII. July 13. Gisund, Solberg Fjord, 120 fms.; mud. *Astrorhiza arenaria* (many very large specimens), worm tubes in the mud.

XIV. July 15. Lekoë Fjord, 130 fms., gravel.
Stylocordyla stipitata, Cydonium sp., *Craniella zetlandica, Erylus* sp. and *Myxilla* sp.
Actinians (large red sp.).
Asterids, Ophiurids, Echinids, *Brissus* sp., *Goniaster* sp., Antedon sp.
Worm tubes.
Rhabdopleura mirabilis.
Scalpellum sp., Isopods.
Waldheimia septata, Astarte sulcata, Neœra obesa, Arca pectunculoides var. *septentrionalis, Trophon clathratus* var., *Scaphander lignarius.*
Microcosmus (?)., and *Ciona.*

XV. July 16. Throndhjem Fjord, off Rodberg, 300 fms. Many sponges.
Podocoryne sp., *Lafoëa fruticosa* (on *Flustra*), *Calycella fastigiata, Filellum serpens, Sertularella polyzonias, Diphasia tamarisca.*
Muricea sp., *Lophohelia prolifera, Kophobelemnon* sp.
Psolus phantapus, Holothuria intestinalis, Antedon sp., Asterids and Ophiurids.
Terebratula cranium and *T. caput-serpentis.*
Æga ventrosa, Pardalisca cuspidata.
Lima excavata (many), *Pecten aratus, Modiola* sp., *Astarte sulcata, Arca pectunculoides* var. *septentrionalis, Limopsis minuta, Leda min-*

uta, L. pygmæa, Nucula nucleus, Acmæa virginea, Bela rufa (?), Chiton sp.

Ascidia sp. (like July 6).

XVI. July 16. Throndhjem Fjord off Stadsbygt, 150 fms., mud and stones.

Lima excavata (many, alive, some with the sponge *Alectona millari* boring in the shell).

XVII. July 18. Molde Fjord, 150—200 fms., mud.

Kophobelemnon sp.

XVIII. July 19. Moldoen, dredging from small boat, 20 fms. to shore.

Astropecten sp., Ophiurids, *Echinocyamus pusillus, Echinus miliaris.*

Worm tubes, *Pagurus* sp.

Pecten maximus, Modiola modiolus, Venus ovata, Dentalium entale, Cerithium sp., *Lacuna crassior, Acmæa* sp., *Trochus* sp., *Turritella* sp., *Aporrhais pes-pelicani.*

Ascidia sp. (test), *Eugyra.*

XIX. July 19. Reksten Fjord, 200—300 fms.

Plumohalichondria sp., *Myxilla* sp., *Melonanchora elliptica.*

Campanularia verticillata, Obelia flabellata, Actinia sp.

Stichopus natans, Holothuria intestinalis.

Aphrodite sp. and worm tubes.

Galathea sp.

Polyzoa: 23 species (5 species on one small stone), see list, p. 90.

Terebratula cranium, Dentalium entale.

XX. July 20. Napsvaag, 10—20 fms., dredging from ship while at anchor, as at Havösund on July 10.

Sponge on Alga.

Pectinaria sp.

Anomia ephippium and *Dentalium entale.*

Foraminifera.

Dr. G. W. Chaster has made a careful examination of the mud and other "dredge debris" kept, and of the old shells, stones, &c., and has drawn up the following list of the Foraminifera obtained. The roman numerals in brackets refer to the localities in the preceding list (beginning p. 79).

Biloculina bulloides, d'Orb. (VIII, IX), *B. ringens*, d'Orb. (VI), *B. sphæra*, d'Orb. (X), *B. comata*, Br. (XVI), *B. elongata*, d'Orb. (VIII), *B. depressa*, d'Orb. (VI), *Spiroloculina limbata*, d'Orb. (XV), *Sigmoilina tenuis*, Czjzek (XIX), *S. celata*, Costa (XV), *Miliolina seminulum*, L. (III), *M. oblonga*, Mont. (XIX), *M. trigonula*, Lmk. (XVI), *M. tricarinata*, d'Orb. (VIII), *M. subrotunda*, Mont., *M. auberiana*, d'Orb., *M. contorta*, d'Orb., *Ophthalmidium inconstans*, Br. (X), *Cornuspira involvens*, Reuss (XIX), *C. carinata*, Costa, *Jaculella obtusa*, Br. (I), *Astrorhiza arenaria*, Nor. branched form, *A. crassatina*, Br. (X, XV), *Hyperammina elongata*, Br. (I), do. var. *lævigata*, Wr. (VIII), *H. ramosa*, Br. (I), *Reophax scorpiurus*, Montf., *R. fusiformis*, Will., *R. nodulosa*, Br. (XII), *Haplophragmium pseudospirale*, Will., *H. latidorsatum*, Born., (I), *H. glomeratum*, Br., (XII), *H. canariense*, d'Orb. (VIII), *H. globigeriniforme*, P. and J., *Rhabdammina abyssorum*, M. Sars (VIII, IX), *Ammodiscus incertus*, d'Orb. (VI), *A. gordialis*, P. and J. (X), *A. charoides*, P. and J. (XIV), *A. shoneanus*, Sidd. (VIII), *Trochammina nitida*, Br. (X), *T. robertsoni*, Br. (XIX), *T. ochracea*, Will. (XIX), *Webbina clavata*, P. and J. (I), *Textularia gramen*, d'Orb., *Spiroplecta sagittula*, Def. (VI), *Bigenerina nodosaria*, d'Orb. (VI), *B. digitata*, d'Orb. (I), *Gaudryina subrotunda*, Schw. (VI), *G. scabra*, Br. (XV), *Verneuilina polystropha*, Reuss (I), *Valvulina conica*, P. and J. (XII), *V. fusca*, Will. (X), *Bulimina pyrula*, d'Orb. (I), *B.*

pupoides, d'Orb. (XII), *B. elegantissima*, d'Orb. (XV), *B. subteres*, Br. (VI), *B. marginata*, d'Orb. (VIII), *B. aculeata*, d'Orb. (XIV), *B. convoluta*, Will. (XIV), *B. fusiformis*, Will. (XV), *B. affinis*, d'Orb., *Virgulina schreibersiana*, Czjzek (XIV), *Bolivina punctata*, d'Orb. (XIX), *B. dilatata*, Reuss (X), *B. variabilis*, Will., *B. difformis*, Will. (XIX), *B. plicata*, d'Orb. (XV), *Cassidulina lævigata*, d'Orb. (X), *C. crassa*, d'Orb. (VI), *C. bradyi*, Nor. (XIX), *Chilostomella ovoidea*, Reuss (I), *Seabrookia earlandi*, Wr., *Lagena globosa*, Mont. (XV), *L. apiculata*, Reuss, *L. lævis* var. *gracillima*, Seg. (XIX), *L. striata*, d'Orb. (XIX), *L. lineata*, Will. (VIII), *L. sulcata*, W. and J. (I), *L. costata*, Will. (VI), *L. williamsoni*, Alc. (I), *L. striato-punctata*, P. and J. (XIX), *L. gracilis*, Will. (XIV), *L. semistriata*, Will. (XII), *L. squamosa*, Mont. (I), *L. hexagona*, Will. (XII), *L. lævigata*, Reuss (I), *L. quadrata*, Will. (X), *L. marginata*, W. and B. (VI), do. var. *semimarginata*, Reuss, *L. trigono-marginata* (XIX), *L. lagenoides*, Will. (XIX), do. var. *tenuistriata*, Br. (X), *L. ornata*, Will. (XII), *L. pulchella*, Br. (XIX), *L. fimbriata*, Br. (XIX), *L. orbignyana*, Seg. (X), do. var. *variabilis*, Wr., *L. clathrata*, Br., *Nodosaria rotunda*, Reuss (VIII), *N. communis*, d'Orb., *N. scalaris*, Bats. (XII), *N. lævigata*, d'Orb. (XV), *N. calomorpha*, Reuss, *Marginulina glabra*, d'Orb., *Lingulina carinata*, d'Orb. (XIX), *Vaginulina legumen*, L., *V. linearis*, Mont. (X), *Cristellaria crepidula*, F. and M. (XV), *C. vortex*, F. and M., *C. cultrata*, Montf. (XVI), *C. compressa*, d'Orb. (IX), *C. gibba*, d'Orb. (XV), *C. obtusata*, Reuss (IX), *Polymorphina lactea*, W. and J., *P. sororia*, Reuss (VI), *P. compressa*, d'Orb. (VIII), *Uvigerina pygmæa*, d'Orb. (VI), *U. angulosa*, Will. (X), *Sagrina dimorpha*, P. and J. (XV), *Globigerina bulloides*, d'Orb. (XV), *Orbulina universa*, d'Orb., *Pullenia sphæroides*, d'Orb. (XV), *P. quinqueloba*,

Reuss (I), *Sphæroidina bulloides*, d'Orb., *Spirillina vivipara*, Ehr. (XIX), *S. obconica*, Br., *Patellina corrugata*, Will. (VIII), *Discorbina globularis*, d'Orb., *D. rosacea*, d'Orb. (XII), *D. nitida*, Will. (XIV), *D. minutissima*, Chaster (XV), *D. bertheloti*, d'Orb. (VIII), *D. orbicularis*, Terg. (XIX), *D. opercularis*, d'Orb., *Truncatulina refulgens*, Montf. (I), *T. lobatula*, W. and J. (XII), *T. ungeriana*, d'Orb. (III), *Anomalina coronata*, P. and J. (X), *Pulvinulina karsteni*, Reuss (XV), *P. exigua*, Br. (XV), *P. elegans*, d'Orb. (XV, XVI), *P. repanda*, var. *concamerata*, Mont., *P. concentrica*, P. and J. (XV), *P. auricula*, F. and M. (XIV), *Rotalia beccarii*, L., *R. orbicularis*, d'Orb. (XII), *Nonionina depressula*, W. and J., *N. umbilicatula*, Mont. (XII), *N. stelligera*, d'Orb. (III), *N. scapha*, F. and M. (XII), *N. turgida*, Will. (XIV), *Polystomella striatopunctata*, F. and M. (I), *P. crispa*, L. (XV), *Operculina ammonoides*, Gron. (I), *Placopsilina vesicularis*, Br. (VIII, IX).

Porifera.

Dr. R. Hanitsch reports that the "Argo" collection contains about 30 species of Sponges, representing about 25 genera. The majority are Monaxonida, 5 or 6 are Tetractinellida, 2 are Calcarea, and there is one doubtful member of the Ceratosa. The Hexactinellida are not represented.

Several of the genera are now recorded, it is believed, for the first time from Norway although they are known from neighbouring seas. These are *Oceanapia*, *Gellius*, *Tedania*, *Plumohalichondria*, *Iophon*, *Melonanchora*, *Erylus*, and *Cydonium*.

Amongst other interesting forms which were dredged may be mentioned:—*Alectona millari* boring in the large shells of *Lima excavata*, *Stylocordyla stipitata* which

although mainly a northern form extends also into other seas and has been recorded from Grenada and Bahia, and *Craniella zetlandica*, some splendid specimens of pure white, lemon yellow and ruddy brown colours. The last two species were obtained near Lekoë, where also some very large specimens of *Myxilla* sp. and *Cydonium* sp. were hauled up.

Cœlenterata.

The few Zoophytes collected have been recorded in the list of localities (p. 79). *Stylaster gemmascens* and possibly a couple of other species of Stylasterids were obtained.

The Alcyonaria include the following:—

Kophobelemnon sp., *Protoptilum* sp., *Trichoptilum* sp., *Clavularia arctica*, *Muricea placomus*, *Briareum grandiflorum*, *Paramuricea ramosa*.

Lophohelia prolifera and *Amphelia ramea* were also found, and a number of Actinians which have not yet been examined.

Echinodermata.

A considerable number of Echinodermata were obtained, of which the following species have been identified by Miss Buckley:—*Antedon sarsii*, *Astrophyton linckii*, *Astropecten arcticus*, *Archaster parelii*, *Stichaster roseus*, *Echinus miliaris*, *E. elegans*, *Strongylocentrotus drobachiensis* (some with 8 pairs of pores in arc), *St. lividus*, *Echinocyamus pusillus*, *Brissus* sp., *Stichopus natans*, *Chirodota (?) Thyone raphanus*, *Holothuria intestinalis*, *Cucumaria frondosa*, and *Psolus phantapus*.

The Vermes have not been determined, with the exception of *Rhabdopleura mirabilis*, from Kors Fjord and Lekoë Fjord. The following Polyzoa have been identified by Miss L. R. Thornely. The roman numerals indicate the stations (see p. 79) at which the species were obtained.

Polyzoa.

Menipea sp., VI, VIII.

Cellularia ternata, Smitt, VIII.

Scrupocellaria scabra, Hincks, VIII, XIX.

Caberea ellisii, H., VI, VIII, X.

Bicellaria alderi, H., VI.

Bugula murrayana, H., VIII.

Flustra barleei, H., VI, and *F. securifrons*, H.

Membranipora lineata, H., VIII, XIX, *M. sophia*, VIII, *M. minax*, H., X, XIX, *M. aurita*, Pet., XIX, and *M. cornigera*, H., XIX.

Cribrilina punctata, S., X.

Microporella ciliata, H., and *M. impressa*, H., X, XIX.

Escharella porifera, var. *pertusa*, S.

Anothiopora monodon, S., XIX.

Schizoporella alderi, H., (2 vars). X, *S. auriculata*, H., and *S. sinuosa*, H., VIII.

Myriozoum coarctatum, S., VIII.

L. pallasiana, VIII, *Lepralia spathulifera*, S., VIII, *L. pertusa*, H., XIX, and *L. hippopus*, S., XIX.

Porella compressa, H., VIII, XIX, *P. concinna*, H., VIII, X, XIX, *P. lævis*, var. *lepralia*, S., VIII, X, and *P. struma*, H., XIX.

Eschara verrucosa, var. *costata*, S.

Escharoides rosacea, H., VIII, XIX.

Discophora coccinea, S., VIII, XIX, and vars. *peachii*, *ventricosa*, *labiata*, XIX. *D. sincera*, S.

Mucronella peachii, H., var. *octodentata*, X, XIX, *M. coccinea*, VI, X, XIX, *M. pavonella*, X, XIX, and *M. microstoma*, H., X.

Cellepora ramulosa, S., var. *contigua*, and var. *avicularis*, *C. scabra*, VIII, and *C. incrassata*, S. VIII, XIX.

Retepora beaniana, H., VIII, XIX, *R. cellulosa*, Cav., and do. var. *elongata*, S.

Stomatopora granula, H.
Idmonea serpens, H., VI.
Diastopora obelia, H., VIII, X, and *D. repens*, S.
Hornera lichenoides, VI, VIII, X, XIX.
Tubulipora atlantica.
Cylindræcium sp., VIII.

The CRUSTACEA and the MOLLUSCA have been already mentioned under the list of localities (p. 79). Finally the TUNICATA form a large collection of from 25 to 30 species represented by several hundred specimens. I am now examining them in detail with the assistance of Miss J. H. Willmer. As we are going over every specimen with the view of determining the variations, and as Canon Norman has kindly sent me the collection of Ascidians he made last year in Finmark in order that they might be examined along with the "Argo" specimens, it will be some weeks before the descriptions and drawings are finished. Consequently as it is desirable that this general account of the results of the "Argo" cruise should not be further delayed, I shall give here a preliminary list of the Tunicata so far as they have yet been identified, leaving the detailed account for a separate report, like that on the Sponges by Dr. Hanitsch.

ASCIDIÆ SIMPLICES.

Molgula septentrionalis, Tr., St. VIII, 50 fms.
M. sp. (? n.sp.) do.
[In some respects like *Molgula euprocta* and *M. impura*, but apparently distinct from both.]
Eugyra sp., St. XVIII, Moldoen, 20 fms.
Microcosmus molguloides, n.sp., St. VIII, 50 fms.
[A remarkable form covered all over with sand, and with only 5 folds on each side of branchial sac.]
Cynthia echinata, L., St. VIII and IX, 50—75 fms.
[Some very good specimens.]

Rhabdocynthia pyriformis, St. IX, 75 fms.
[One, small.]
Styela rustica , L., St. VIII and IX, 50—75 fms.
[very abundant.]
St. monoceros, Moll., do.
[From the examination of a large number of specimens we are convinced of the distinctness of these two forms.]
St. sp. (? n.sp.), St. II., Ask, 200 fms.
[A small depressed sandy form resembling a *Molgula*.]
Polycarpa sp., n.sp., St. IX, 75 fms.
Ascidia obliqua, Alder, St. VIII and IX, 50—75 fms.
[And another allied form, probably distinct.]
A. sp., n.sp., St. XII, Tromsö, 70 fms.
[Near *Ascidia glacialis*, but differs in some respects.]
A. sp., n.sp., St. VI and XV, Throndhjem, 300 fms.
[In some respects like *Ascidia curvata*.]
Ciona intestinalis, L., St. XIV, Lekoë, 130 fms.
Rhopalopsis, sp. (?), St. VI, Throndhjem, 300 fms.
[Thick grey gelatinous test like *Ascidia*; branchial sac, &c., like *Rhopalopsis* or *Ecteinascidia*.]

ASCIDIÆ COMPOSITÆ.

Distoma (?) sp., St. VIII and IX, 50—75 fms.
[A pedunculated yellow form.]
Distoma sp., St. XII, Tromsö, 70 fms.
[Small grey colonies.]
Amaroucium sp., St. VIII and IX, 50—75 fms.
[Large rounded red colonies.]
Amaroucium sp. do.
Didemnum sp., St. III, Stav fj., 200 fms.
[A massive form, possibly referable to the newly established genus *Sarcodidemnoides*.]
Leptoclinum (2 species) St. VIII and IX, 50—75 fms.

Goodsiria n.sp., St. X, 150 fms.

[A slate coloured form—small rounded colonies.]

Pseudodidemnum sp., St. IX, 75 fms.

[A soft loosely arranged yellow layer.]

And possibly a few other species.

Explanation of Plates.

Plate VI.—Rough outline of the West and North Coasts of Norway to shew approximately the relative positions of the dredgings (I—XX) and tow-nettings (1—34).

Plate VII.—Biologist's portable work table, for use on board ship.

RECORD of Additional HYDROIDA from the ISLE OF MAN.

By G. W. Wood, F.I.C.

[Read April 8th, 1892.]

I have much pleasure in submitting to the Biological Society a list of some Hydroida from the Isle of Man, which have not been previously recorded.* I have made numerous dredgings there during the last few years, chiefly in moderately deep water (20—30 fathoms). The forms belonging to other groups which I have preserved may be reported upon on some future occasion.

Hydroida have also been procured for me by some of the Manx trawlers, and parcels continue to be forwarded from time to time, so that the present list is likely to be extended. I have confined my attention to the fauna of the N.W. and N.E. coasts, the south end of the Island having already been investigated during the L.M.B.C. dredgings, and those of Prof. Herdman, as recorded in the first volume of the Fauna of Liverpool Bay.

Although the area represented by the Isle of Man is comparatively small, the habitats of some of the species are somewhat sharply defined. Some of the species found by the L.M.B.C. in the S. and other species reported from the N. are altogether absent from the N.E. and N.W. and *vice versa*. *Diphasia pinaster*, a species not hitherto reported from the N. or S., is quite common in the N.W. but absent again in the N.E. Another species, *Sertularia*

* [The Report upon the Hydroida of the L.M.B.C. District will be found in Vol. I. of the "Fauna of Liverpool Bay," p. 95.—Ed.]

argentea, which is abundant (in the young state) in the N.E. is represented in the N.W. by only two or three small fragments, and only "several *very* small pieces" were obtained by the L.M.B.C. in the S. Of the rare *Thuiaria articulata* I have found several good specimens in the N.W., none on the other side. I have also dredged fine specimens of *Aglaophenia myriophyllum* in plenty off the Dhoon, but one small colony only has appeared in the N.W. Neither of the two last-named species has, I believe, been reported from the Isle of Man since the time of Forbes.

As a summary of my results up to the present time I have the gratification to record 12 Hydroida not hitherto reported from the Isle of Man, of which 5 are new to the district of Liverpool Bay. They are as follows:—

New to Isle of Man only.

Tubularia coronata, Abildg. From the N.W.
Obelia geniculata, Linn. From the N.W. and N.E.
Obelia longissima, Pallas. From the N.W.
Diphasia attenuata, Hincks. From the N.W. & N.E.
Diphasia pinaster, Ellis and Sol. From the N.W.
Diphasia tamarisca, Linn. From the N.W.
Sertularia cupressina, Linn. From the N.W.

New to the Isle of Man and L.M.B.C. district.

Tubularia attenuata, Allman. From the N.W.
Campanularia (?) raridentata, Alder. From the N.W.
Halecium muricatum, Ellis and Sol. From the N.E.
Halecium tenellum, Hincks. From the N.E.
Sertularella tenella, Alder. From the N.W. and N.E. (abundant).

REVISION of the PODOPHTHALMATA and CUMACEA of LIVERPOOL BAY to May, 1892.

By Alfred O. Walker, F.L.S.

[Read May 13th, 1892.]

The following list comprises all the Podophthalmata and Cumacea recorded from Liverpool Bay up to date. The Edriophthalmata will follow, but it is considered advisable to delay these until the completion of Prof. G. O. Sars' fine work on the Amphipoda of Norway so that our species may be named in accordance with it.

In the references to the Reports previously published it may be well to mention that Rep. I, is contained in the first volume of the Reports of the Liverpool Marine Biological Committee, (1886) pp. 221—226; Report II and III, are in the second vol. of the above (1889) pp. 171—181 and App. pp. 68—86; Rep. II, is also published in the Proceedings Liverpool Biological Society, Vol. II, 1887—8, pp. 171—181; Rep. III, in Vol. III, 1888—9, pp. 195—213; and Rep. IV, in Vol. IV, 1889—90, pp. 239—51.

PODOPHTHALMATA,

Brachyura.

Gonoplax angulata, Fabr. (Rep. I, 225).

One specimen said to have occurred at Southport (C. H. Brown). A Mediterranean species.

Pinnotheres pisum, Penn. (Rep. I, 225).

In Mussels as a commensal.—Dawpool; Conway; Coast of I. of Man.

Corystes cassivelaunus, Herbst (Rep. I, 225.)

Not uncommon on sandy ground at various depths and between tidemarks throughout the district.

Thia polita, Leach. (Rep. I, 224).

Constable Bank, "Hyæna," 1885, 10 to 17 miles N.W. of Mersey Bar; "Spindrift," 1890.

Atelecyclus septemdentatus, Mont. = *A. heteroden*, Leach.

Off Fleswick Bay, Station I, 20 fath., 2 specimens, and Station III, 30 to 33 fath. 1 specimen, June 5, '92.

Platyonychus latipes, Penn., *Portumnus variegatus*, Leach. (Rep. I. 225. II, 180).

Between tidemarks on sand in which it buries itself. Penmaenmawr. Colwyn Bay.

Carcinus mœnas, Baster (Rep. I, 225).

Very abundant in the Dee and Mersey. Not so common at Colwyn Bay.

Portunus puber, Linn. (Rep. I, 225, III, 69).

Point of Ayr, 1875. Bull Bay, Anglesey.

Portunus depurator, Linn. (Rep. I, 225).

Abundant everywhere: generally on stony ground 3 to 7 fath.

Portunus arcuatus, Leach. (Rep. I, 225).

Mouth of the Dee. Colwyn Bay. Not common.

Portunus holsatus, Fabr. (Rep. II, 180).

Garth Ferry, Menai Straits—10 fath. (H. C. Chadwick)

Portunus pusillus, Leach. (Rep I, 225, IV, 243).

Port Erin, I. of Man; Dulas Bay, Anglesey.

Pilumnus hirtellus, Penn. (Rep. I, 225, II, 180).

Orme's Heads; Puffin Island; Bar of Dee. Shore to 15 fathoms.

Xantho rivulosus, Risso, and var. *tuberculatus*, Couch (Rep. II, 180, III, 69, IV, 244).

Beaumaris, shore (Chadwick). Port Erin. 16 miles N. of Holyhead 40 to 60 fath. "Spindrift," 20/7/89.

Cancer pagurus, Linn. (Rep. I, 226).

Rhos and Colwyn Bays: Common but small.

Eurynome aspera, Penn. (Rep. I, 226, II, 180).

Puffin Island, 15 fath. S. end of I. of Man. Between Liverpool and I. of Man, 20 and 30 fath.

Hyas araneus, Linn. (Rep. I, 226).

Off the Little Orme; Puffin Island, &c., in stony places 2 to 10 fath.: not so common as the next species.

Hyas coarctatus, Leach. (Rep. I, 226).

Stony places, shore to 10 fath. Common.

Inachus dorsettensis, Penn. (Rep. I, 226, II, 180).

Off Port Erin; between Liverpool and I. of Man, "Weathercock," 28/8/86.

Stenorhynchus rostratus, Linn. (Rep. I, 226).

Common in stony places.

Ebalia tuberosa, Penn., *E. pennantii*, Leach (Rep. I, 224, II, 180, IV, 243).

S. end of I. of Man; Dulas Bay; between Liverpool and I. of Man "Weathercock," 28/8/86, 20 to 30 fath.

Ebalia tumefacta, Penn., *E. bryerii*, Leach (Rep. I, 224, II, 180, IV, 243).

S. end of I. of Man; "Weathercock," 28/8/86; Dulas Bay, 20 to 30 fath.; Penrhos Bay, May, 1890; 10 to 17 m. N.W. of Mersey Bar, Sept., 1890.

It is remarkable that the two last species, if they be distinct, should have been taken together in every case.

Anomura.

Eupagurus bernhardus, Fabr.

Abundant everywhere.

E. prideauxii, Leach (Rep. I, p. 223).

Off Port St. Mary, Isle of Man (Herdman).

E. pubescens, Kröyer (Rep. III, p. 69).

Dredged W. of Calf of Man, May, 1888, "Hyæna."

Eupagurus cuanensis, Thompson (Rep. I, 224, II, 179).

Off S. end of I. of Man, 1885. Between Liverpool and Isle of Man, 20 to 30 fath., Aug., 1886.

Spiropagurus lævis, Thomp. (Rep. II, 180).

One specimen, Douglas, I. of Man, 1886.

Porcellana platycheles, Pennant (Rep. I, 224).

Under stones at low tide. Colwyn Bay; Hilbre Island; Puffin Island. Sometimes abundant, especially in spring.

P. longicornis, Penn. (Rep. I, 224).

Common everywhere under stones.

Galathea nexa, Embleton (Rep. IV, 243, 244).

Off Anglesey Coast, June, 1889; about 16 miles N. of Holyhead in 40 to 60 fath., July, 20th, 1889; several.

G. dispersa, Bate, (Rep. III, 69, IV, 244).

Off I. of Man, May, 1888, about 16 miles N. of Holyhead, 40 to 60 fath., July 20th, 1889. One specimen taken off Calf of Man, April, 1889, had the 3rd maxillipedes as figured by Henderson, "Anomoura of Challenger Expedition," Pl. XII, fig. 6a.

G. intermedia, Lilljeborg, *G. andrewsii*, Kinahan (Rep. I, 223, II, 179).

Menai Straits; Hibre Swash; Port Erin; between Liverpool and I. of Man, 20 to 30 fath.; coast of I. of Man; rather common.

G. squamifera, Leach (Rep. I, 223).

Off S. end of Isle of Man.

Munida bamffica, Penn. (Rep. III, 70).

Off S. end of I. of Man, May, 1888.

MACRURA.

Palinurus vulgaris, Latreille.

Anglesey Coast near Valley; Isle of Man.

Homarus vulgaris, M. Edw. (Rep. I, 223).

Rhos Bay; Puffin Island; Anglesey Coast; Hilbre Island.

Nephrops norwegicus, Linn. (Rep. I, 223).

Said to have been taken at Holyhead (Bell's Brit. Crust. p. 254).

Carida.

Crangon vulgaris, Linn.

Common; sandy shores.

Crangon allmanni, Kinahan (Rep. II, 179, IV, 243).

Between Liverpool and Isle of Man, 20 to 30 fath., August, 1886, three miles off Dulas Bay, Anglesey, June, 1889; Little Orme.

C. trispinosus, Hailstone (Rep. I, 222, II, 179).

Turbot Hole; Puffin Island; Colwyn Bay low tide.

C. fasciatus, Risso. (Rep. I, 222, II, 179).

Turbot Hole; Colwyn Bay.

C. sculptus, Bell (Rep. I, 222).

Off S. end of Isle of Man.

C. nanus, Kröyer = *C. bispinosus*, Westwood, (Rep. IV, 243,) Turbot Hole, 2 females with ova.

Pasiphœa sivado, M. Edw. (Rep. I, 221).

Mouths of the Dee and Mersey, scarce.

Virbius varians, Leach (Rep. I, 222).

Common in tidal pools and down to 15 fathoms.

Hippolyte spinus, Sowerby (Rep. IV, 224).

One specimen 16 m. N. of Holyhead, 40—60 fath., "Spindrift," July 20, 1889.

H. cranchii, Leach (Rep. II, 179).

Turbot Hole and Puffin Island, low water; Colwyn Bay; Towyn, Anglesey, 5 fath.

H. pusiola, Kröyer (Rep. II, 179).

Turbot Hole, between Orme's Head and I. of Man, 30 fath.; off Porthwen Bay, Anglesey, 21 fath.; Towyn, Anglesea, 5 fath.; Amlwch Bay; Little Orme, 8 to 10 fath.

Caridion gordoni, Bate (Rep. III, 70).

One female with ova, between Calf of Man and Port Erin, May, 1888.

Pandalus annulicornis, Leach (Rep. I, 222).

Abundant everywhere on stony ground.

P. brevirostris, Rathke = *Hippolyte Thompsoni*, Bell. (Rep. I, 222, II, 179, III, 70).

Turbot Hole; between Ormes Head and I. of Man, 30 fath.; S. end of I. of Man, 21 fath.; 16 m. N. of Holyhead, off Red Wharf Bay, 20 fath.; Towyn, Anglesea, 5 fath.

Palæmon serratus, Penn. (Rep. I, 221).

Stony ground; not abundant.

Palæmon squilla, Leach. (Rep. II, 179).

One specimen in tidal pool at Beaumaris (Chadwick).

Palæmonetes varians, Leach.

In brackish water. Wallasey Pool, Birkenhead (W. J. Halls).

Schizopoda.

Nyctiphanes norvegica, M. Sars.

Tow-net, about $1\frac{1}{2}$ m. N. of Puffin Island, 6.30 a.m., November 30, 1890.

Leptomysis lingoura, G. O. Sars.

Colwyn Bay, $2\frac{1}{2}$ fath., Sept. 15, 1890; Port Erin Harbour, 2 to 5 fath., June 4, 1892.

Siriella norvegica, G. O. Sars (Rep. IV, 241, 244-5).

Port Erin, April 20, 1889, Electric Light and tow-net on surface.

Siriella armata, M. Edw.

Puffin Island, tow-net, 1890.

Gastrosaccus spinifer, Goes. (Rep. IV, 241-2).

Colwyn Bay, $2\frac{1}{2}$ fath., October 2, 1889; Port Erin, Electric Light, April 20, 1889.

Mysis flexuosa, Müller (Rep. I, 221).

Dee, off Flint; tidal pools, Rhos Bay, April and May; Puffin Island, S. side.

M. neglecta, G. O. Sars (Rep. IV, 242-245).

Rhos Bay, low tide, June, 1889, July, 1890.

Distinguishable from the last species by the anterior tarsal joints having 5 joints and the posterior 4, instead of 6 and 5 respectively. The antennal scale is also shorter and proportionately wider in this species.

M. inermis, Rathke (Rep. IV, 242).

Colwyn Bay, low tide, Sept., 1889; Puffin Island, off Dinmor Point, April, 1890 (I. C. T.); Douglas, I. of Man, August, 1886; Dulas Bay,

M. spiritus, Norman, tow-net.

Puffin Island, 1890 (I. C. T.)

In Report I, p. 221, for *M. spiritus*, Norman, read *M. kervillei*, Sars.

M. ornata, G. O. Sars (Rep. IV, 242-3, 245).

Colwyn Bay, May, 1887; off Lighthouse, Puffin Island, 1888; Little Orme, 8 fath., August, 1889.

M. kervillei, G. O. Sars, (Bull. de la Soc. des Amis des Sciences Nat. de Rouen, 1885, p. 92, Pl. V. Hoek, Tijdschrift der Nederlandsche Dierkundige Vereen, 1887, p. 11, Pl. VII.)

Little Orme, 8 fath., August, 1889 (with *M. ornata*); 12 to 17 m. N. of Mersey Bar, Sept., 1890; Colwyn Bay, Jan., 1890 and 1891.

I have called the specimens with 5 tarsal joints (excluding the nail) *M. ornata*, and those with 6 joints *M. kervillei*. I am unable to see any other constant difference between the 2 species. I have specimens with 6-jointed tarsi which have the cleft of the telson and the position of the spine of the antennal scale (which are the parts relied upon by the author for the specific difference in addition

to the tarsal joints), exactly the same as other specimens which have only 5-jointed tarsi.* Generally the spine is nearer to the apex of the antennal scale than to the base. The colour of *M. kervillei* is greyish-white, thorax spotted with dark red or brown, one dorsal and two lateral (one on each side) spots on each abdominal segment; proximal fourth of telson also dark red, succeeded by a white arborescent patch.

M. lamornæ, Couch (Rep. II, 178).

Colwyn Bay, May, 1887, 3 fath.; Little Orme, August, 1889, 8 fath.

M. vulgaris, Thompson (Rep. II, 178).

Mouth of the Alt, in brackish water.

CUMACEA.

Cuma scorpioides, Montagu = *C. edwardsii*, Goodsir (Rep. III, 70; IV, 242-3, 246).

Off Great and Little Ormes, 5 to 10 fath.; Ramsey at Electric Light and Port Erin, males and females, 3 fath. below surface; Dulas Bay and Porth Dafarch, Anglesey; Puffin Island; Hilbre Swash; Menai Straits. For remarks on the identity of *C. scorpioides* and *C. edwardsii* see Rep. IV, 246.

Iphinöe trispinosa, Goodsir = *I. gracilis*, Sp. Bate and Sars, Middelhavets Cumaceer p. 36, Pl. 10—14. *Iphinöe serrata*—Norman—under Plates (Rep. III, 71, IV, 242.)

Port Erin at Electric Light, very abundant; Colwyn Bay 2½ fath. dredged, ; Puffin I. 5 fath.; Porth Dafarch, Anglesey.

The females only have a row of spines on the dorsal surface of the cephalothorax. An old male measured 11½ mm., colour bright red.

* I have also an adult male with the cleft of the telson and antennal scale as figured for *M. kervillei* but with 7-jointed tarsi.

Cumopsis goodsiri, Van Beneden = *Bodotria goodsiri*, Van Ben. Recherches sur la Faune littorale de la Belgique, p. 77, Pl. XIII = *Cumopsis goodsiri*, Van Ben.—G. O. Sars, Middelhavets Cumaceer p. 52, Pl. XIX to XXI.

One female in tow-net off Puffin I. Nov. or Dec. '90; several young dredged off Puffin I. in 10 fath., July '91 (I.C.T.).

Lamprops fasciata, G. O. Sars. Om den aberrante Krebsdyrgruppe Cumacea, Christ. Vid.—Selsk. Forhandl. 1864—(Rep. IV, 242/3, 247.) Colwyn Bay, 2½ fath.; 3 miles off Dulas Bay, 20 fath.; Little Orme 8 fath.; Puffin I. 5 fath.

Eudorella truncatula, Sp. Bate = *Eudora truncatula*, Sp. Bate, Ann. & Mag. Nat. Hist. Ser. 2, Vol. 17, p. 457, Pl. XIV. Off S.W. end of Puffin I. 5 fath. May '90, Colwyn Bay, 1 young male, colour pure white.

Diastylis rathkei, Kröyer, (Rep. IV, 249), Little Orme --two immature males; Puffin I. 5 fath, off S.W. end, two females.

Diastylis spinosa, Norman (Rep. II, 178, Pl. XIII, f. 10 Rep. IV, 242, 247). Male = *D. Bradyi*, Norman, female.

Colwyn Bay—females and young abundant, males scarce; Puffin I. 5 fath. S.W. end, two females; Towyn 5 fath.

For remarks on the identity of the above species see Rep. IV, 247.

Pseudocuma cercaria, Van Beneden, (Rep. III, 71, IV, 242, 248.)

Port Erin at Electric Light—males only, abundant; Colwyn Bay, abundant; Puffin I. 5 fath.

SUPPLEMENTARY REPORT upon the TESTACEOUS MOLLUSCA of the L.M.B.C. DISTRICT.

By the late Francis Archer, B.A.

[Read 13th May, 1892.]

Editorial Note.

It is well known to members of the Biological Society that for some years past the late Mr. F. Archer has had charge of the Mollusca obtained in the dredging and other collecting expeditions, and has been accummulating material for a report supplementary to that given by Mr. R. D. Darbishire in the first volume of the "Fauna of Liverpool Bay."

During last winter Mr. Archer decided that his records and notes were sufficiently complete to permit of publication this session, so the title of the report was printed on the Society's circular for reading at the March meeting. After his sudden death in February, and in consultation with his brother Surgeon-Colonel S. Archer, it was decided that the report (the materials for which were found very carefully and systematically recorded in five large note books) should be edited and published with as little delay as possible, in order that it might be incorporated in the forthcoming volume III of the "Fauna" as originally intended. At Surgeon-Colonel Archer's suggestion I wrote to his brother's friend Mr. Brockton Tomlin, of

Chester, and asked him to undertake the responsible work of putting the notes and records in proper form for the printer. This Mr. Tomlin kindly consented to do, and the following report has accordingly been arranged and corrected by him. I wish as editor of these L.M.B.C. reports to thank Mr. Tomlin, and express the satisfaction of the Committee, that one so eminently qualified both as a conchologist and also from his knowledge of Mr. Archer's collections and notes and methods should have been found willing to undertake this work, and carry it out without delay. The following introduction is by Mr. Tomlin.

W. A. H.

Introduction.

This Report is strictly supplementary, and must be read entirely by the side of that in vol. I of the "Fauna," pp. 232—266. Nor must it be supposed that *all* new records are included, especially in the case of the commoner species, the aim being primarily to record extensions in the habitat or apparent habitat of the species, but not to publish all the occurrences of dead specimens, while our knowledge of the district is so imperfect and the collecting disconnected. It will be noticed that the chief centres of thorough exploration since last report have been Port Erin in the Isle of Man and the N. and E. coasts of Anglesea, all worked by the late F. Archer: the Southport neighbourhood by Dr. G. W. Chaster: Fleetwood by W. H. Heathcote and others: and the central area by means of several dredging expeditions, the details of which will be found in the successive annual reports upon the work of the L.M.B.C.

To the list of 1886 we are enabled to add 37 species (marked by asterisks in the following pages), of which the *Spirula* is a pelagic cephalopod, accidentally drifted to our shores. The 9 species enclosed in square brackets are for various reasons doubtful. Five of them, viz., *Pinna rudis*, *Trochus lineatus*, *Odostomia conoidea*, *O. pusilla*, and *Cerithiopsis tubercularis*, may quite possibly occur but require confirmation: *Donax trunculus* is a certain error in Rep. I and should be expunged, the specimens being referable to *D. vittatus*: *Aplysia depilans* is an almost equally certain error: *Fusus islandicus* of Forbes and C. H. Brown = *F. gracilis*, DaC.; while there is much reason to believe that *Cardium echinatum* was mistaken for *C. aculeatum* by Forbes in his "Malacologia Monensis."

The following should be added to the bibliographical references on p. 247 of Rep. I.

Forbes and Hanley's "History of Brit. Mollusca" (1853).

Dr. J. G. Jeffrey's "Brit. Conchology" 5 vols. (1863).

Thos. Pennant's "Brit. Zoology" vol. IV (1777).

Chas. H. Brown's Mollusca in Dr. Nichol's "Southport," 3rd edition (1883).

Rev. Carleton Greene's "Marine Moll. of N. Wales" in "The Conchologist" vol, I, No. 1.

B. Tomlin's "Notes on N. Wales Mollusca" in "Quarterly Journal of Conchology," vol. VII, No. 1 (Jany., 1892), also containing some corrections of Rev. C. Greene's paper.

Dr. G. W. Chaster's "Mollusca of Southport and District" in Rep. I of Southport Soc. Nat. Sc. (1892).

BRACHIOPODA.

**Crania anomala*, Müll., omitted in Rep. I.

A single specimen dredged off Ballaugh in 1834 by Forbes (Mal. Mon.).

MOLLUSCA.

Lamellibranchiata.

Anomia ephippium, L.

The vars. *squamula*, *aculeata*, *cylindrica* are all recorded from the I. of Man. General throughout the district but characteristically dwarfed.

Anomia patelliformis, L.

Common at Port Erin (F.A.): var. *striata* common on shells in deep water (Forbes; Mal. Mon.).

Ostrea edulis, L.

Recorded by Forbes as plentiful off N. and E. coasts of I. of Man, a bank existing off Laxey (Mal. Mon.); two beds known to exist off Bull Bay, Anglesea: occasionally brought in alive to Southport (C.H.B.): beds used to exist on Penmon side of Redwharf Bay, at Pwll Buchan, and at Dulas Bay.

Pecten varius, L.

common living, 5 m. outside Fleetwood, especially a white var.

Pecten opercularis, L.

A bed outside Port Erin and smaller patches nearer shore, especially off Bradda Head (F.A.).

Pecten tigrinus, Müll.

Occasionally living, Port Erin (F.A.): Birkdale, valves rare (G.W.C.).

**Pecten striatus*, Müll., omitted in Rep. I.

Isle of Man (Jeff. B.C. II, 70).

* The additions to the former list are marked by an asterisk.

Pecten similis, Laskey.

Valves only from dredgings off Puffin I. ("Hyæna"), Southport, Bay Fine (common), and in Central area.

Lima loscombii, Sow. see Rep. I. since taken alive.

Two living at Bull Bay in 20 fms. (F.A.): also alive off Bradda Head and Bay Fine (F.A.).

[*Pinna rudis*, L.

The keeper of the cave on the Gt. Orme's Head shows a large specimen said to have been dredged 7 or 8 miles off shore. Query—British at all?]

Mytilus modiolus, L.

Many dredged living 5 miles off Fleetwood: living off Port Erin (F.A.).

Mytilus barbatus, L.

Many off Fleetwood with the last.

Modiolaria marmorata, Forb.

Common near Southport in tests of Ascidians and in *Alcyonium digitatum* (G.W.C.): also in Ascidians off Fleetwood.

Modiolaria discors, L.

Abundant in rockpools, Moelfre Bay, and occasional at Bull Bay (F.A.): Southport, rare in *Alcyonium* (C.H.B.).

Nucula nucleus var. *radiata*, F. and H.

Commoner than type at Port Erin (F.A.): fairly c. alive in central area: Bull Bay, occasional (F.A.).

Nucula nitida, Sow.

Has now occurred commonly alive at Tynygongl, Bull Bay (F.A.), Carnarvon Bay ("Hyæna," 1890), and in central area: rare alive Birkdale (G.W.C.): Port Erin occasional (F.A.).

Leda minuta, Müll.

Carnarvon Bay, alive ("Hyæna," 1890): abundant, living off Amlwch (F.A.): occas. living in central area.

Lepton squamosum, Mont.

One perfect but dead, 20 m. W. of Southport (G.W.C.).

**Lepton nitidum*, Turton.

New to the district: 5 specimens in dredgings from central area and several in the same from Port Erin (F.A.).

Montacuta substriata, Mont.

Common in central area on *Spatangus purpureus*.

Montacuta bidentata, Mont.

Now very common, dead on Birkdale shore (G.W.C.), cf Rep. I: dead also in most localities.

**Lucina spinifera*, Mont.

New to district: several dead off Bay Fine (F.A.).

Lucina borealis, L.

Dead shells and valves common off Port Erin (F.A.).

Cyamium minutum, Fab.

Common alive in weed at Bay-ny-Carrickey, and at Porthwen, Anglesea (F.A.).

[*Cardium aculeatum*, L.

Point of Air, Isle of Man, dead only (Forbes Mal. Mon.) but an extremely doubtful record and should almost certainly be referred to *C. echinatum*: cf. Jeff. B.C. II, 269.]

Cardium echinatum, L.

An immense quantity thrown up at Southport in January, 1891, many alive (G.W.C.): living but generally young off Port Erin, Bull Bay, Tynygongl (F.A.) and in central area.

**Cardium nodosum*, Turton.

New to district: common alive off Bay Fine and Bradda Head (F.A.): central area and Bull Bay (F.A.) valves only.

Cardium norvegicum, Sp.

Very large and living off Morecambe (W.H.H.): valves only, of general occurrence.

Astarte sulcata, DaC.

Frequent alive in Carnarvon Bay ("Hyæna," 1890): sparingly off Bradda (F.A.): rare alive on Birkdale shore (G.W.C.).

var. *scotica*, M. and R. Isle of Man, N., rare in deep water (Mal. Mon.).

**Venus chione*, L., omitted from Rep. I.

Carnarvon Bay in 12 fms. (McAndrew), cf. Jeff. B.C. II, 333: valves in same loc. (Forbes and F.A.). This is the northern limit of the species on our coasts.

Venus fasciata, DaC.

Common alive at Beaumaris (R.D.D.), off Port Erin (F.A.), at Llandudno, in 1878 (B.T.), and in Carnarvon Bay ("Hyæna," 1890): records numerous.

Venus ovata, Penn.

Frequent alive at Port Erin (F.A.), and in Carnarvon Bay ("Hyæna," 1890).

Tapes virgineus, L.

Very abundant at Port Erin and quite the characteristic shell though by far the greater number were fresh dead shells (F.A.): also Bull Bay and Tynygongl (F.A.), Birkdale (G.W.C.), dead only.

Lucinopsis undata, Penn.

One small living specimen in central area, valves common: valves at Port Erin, Tynygongl (F.A.), Southport (G.W.C.).

Tellina fabula, Gron.

Port Erin c. dredged and on shore (F.A.).

**Tellina squalida*, Pult.

Between Southport and Blackpool (W.H.H.), valves only.

Tellina donacina, Don.

c. in central area, young shells alive, adults dead; valves recorded *passim*.

Can any of these "young shells" possibly be *T. pusilla ?*

Psammobia tellinella, Lam.

Abundant in one haul off Bradda Head (F.A.).

[*Donax trunculus*, L.

An undoubted error in Rep. I, p. 252 for *D. vittatus*, DaC. or a variety: the true *D. trunculus* is a mediterranean species of which 2 specimens have occurred on the S. coast of Devon. The mistake must have originated from Forbes' nomenclature, as in his time all British authors called our common species *trunculus*. cf. Jeff. B.C. II, 405.]

Scrobicularia prismatica, Mont.

Occasionally living, more frequent dead at Bull Bay with *S. alba* (F.A.): Port Erin, living (F.A.): very rare at Southport, dead (G.W.C.).

Solen pellucidus, Penn.

Abundantly, living in several parts of central area, and at 4—10 miles W. of Southport: more sparingly at Bull Bay (F.A.).

**Pandora inaequivalvis*, L., omitted from Rep. I.

Isle of Man in 20 fms., and N. Wales in 12 fms. (Forbes, as *P. obtusa*): Carnarvon Bay ("Hyæna," 1890): Port Erin and central area (F.A.): Llandudno (F.A.) all living: one dead specimen at Birkdale (G.W.C.).

Lyonsia norvegica, Chem.

Alive in 20 fms., Isle of Man (Forbes): one fine specimen alive off Bay Fine (F.A.): one dead in central area with valves united.

Corbula gibba, Ol.

Living *passim*, usually frequent.

Mya binghami, Turton.

Moelfre Bay and Bull Bay (F.A.).

Saxicava rugosa, L.

Abundant in many places, living: the var. *arctica*, L. also occurs.

**Teredo navalis*, L.

Southport, once in driftwood (G.W.C.): one valve in sand (W.H.H.). New to district.

SCAPHOPODA.

Dentalium entale, L.

Colwyn Bay (F.A.), and once abundantly in central area—living: dead at Bull Bay and Tynygongl (F.A.).

Dentalium tarentinum, Lam.

Central area, 25 m. N.W. of Bar Lightship, 2 or 3 dead shells ("Spindrift"); several 20 m. W. of Southport (G.W.C.).

POLYPLACOPHORA.

Chiton fascicularis, L.

Scarce living at Porthwen (F.A.) and Llandudno (B.T.).

GASTROPODA.

Tectura testudinalis, Müll.

Now abundant at Fleetwood (W.H.H.): dredged living but small at Port Erin, and one littoral specimen at Llandrillo (F.A.): one fresh shell, Carnarvon Bay ("Hyæna," 1890).

Tectura virginea, Müll.

Common at roots of *Laminaria* on Puffin Is. (A. Leicester): rare living at Llandudno (B.T.): abundant alive off Port Erin (F.A.).

**Puncturella noachina*, L.

New to district. 2 dead in central area dredgings ("Spindrift").

Emarginula fissura, L.

Dead shells of general occurrence. The same applies to *Fissurella græca*, L.

**Cyclostrema serpuloides*, Mont.

Isle of Man in 20 fms. (Forbes, as *Skenea divisa*, Fleming): abundant living on seaweeds at low water in Fleshwick Bay (F.A.).

[*Trochus lineatus*, DaC.

Anglesea (Donovan) in Jeff. B.C. III, 318. This certainly requires confirmation as Forbes (Brit. Assoc. Rep. 1850, p. 255) says that the range of this species ceases in Cardigan Bay or a little higher up, the latter expression probably referring to the S. coast of Carnarvonshire where it does occur.]

Trochus montacuti, Wood.

Frequent living at Port Erin with *T. tumidus* (F.A.).

Trochus millegranus, Phil.

2 or 3 small ones living at Port Erin (F.A.).

Trochus granulatus, Born.

Alive off Morecambe (W.H.H.): occasionally thrown up dead on Lancashire coast.

Trochus zizyphinus, L.

Large and abundant at very low-water, Rhos Point near Colwyn (B.T.).

var. *lyonsii*, Leach. c. alive off Pt. Lynas (Forbes): living at Bull Bay and dead off Tynygongl and in Carnarvon Bay (F.A.).

var. *lævigata*, Sow. Menai Straits and Bull Bay in Anglesea: littoral and dredged at Port Erin (F.A.): Rhos Point (B.T.).

A specimen of the monstrosity mentioned by Jeffreys was dredged in the Menai Straits by Rev. A. H. Cooke.

Lacuna crassior, Mont.

Several alive 5 m. outside Fleetwood, in Sept., 1891.

Lacuna divaricata, Fab.

Young c. in seaweed at Porthwen and Fleshwick Bay (F.A.): abundant on *Laminaria* beyond the pier at Llandudno and of very large size (B.T.).

**Lacuna puteolus*, Turton.

New to the district: Douglas Bay, among sand (Mal. Mon.): small living at Bull Bay, and several off Port Erin (F.A.): one living with *L. divaricata* at Llandudno (B.T.).

Lacuna pallidula, DaC.

Common alive at Moelfre Bay and Porthwen (F.A.), and at Llandudno with the last 2 species (B.T.), where both green and orange forms occur of all sizes.

**Rissoa cancellata*, DaC.

One broken specimen from deep water off the Isle of Man, N. coast (Forbes in Jeff. B.C. IV, 10), omitted from Rep. I.

**Rissoa calathus*, F. and H., omitted from Rep. I.

Isle of Man (Packe in Jeff. l.c. 11).

Rissoa punctura, Mont.

Dredged off Fleetwood (W.H.H.).

Rissoa costata, Ad.

Dead in Bull Bay (F.A.), one at Rhyl (B.T.).

Rissoa parva, DaC.

Abundant, living at Porthwen, Llandrillo, Llandulas Point, and Port Erin district (F.A.): do. at Llandudno (B.T.): Puffin Is. (A. Leicester).

Forbes (Mal. Mon.) says that var. *interrupta* is abundant in Isle of Man, N. but rare at S. and E. where it is replaced by *R. cingillus*.

Rissoa striata, Ad.

Living at Moelfre Bay, Porthwen and Bull Bay (F.A.): at low water on Puffin Is. (A. Leicester.): Fleetwood (W.H.H.).

Rissoa vitrea, Mont.

One in central area: rare in drift at Southport (G.W.C. and C.H.B.).

**Rissoa soluta*, Phil.

Very rare at Southport (G.W.C.).

**Rissoa semistriata*, Mont.

This and the last are new to district: seaweeds at low water, Puffin Is. (A. Leicester): Fleetwood (W.H.H.).

Rissoa cingillus, Mont.

Dead from Bull Bay, Porthwen (F.A.): abundant above Laminarian zone at Port Erin and Bay-ny-Carrickey (F.A.).

**Hydrobia ventrosa*, Mont.

var. *ovata*, Jeff. Débris at h.w. mark near the border of Pilling Marsh (W.H.H.).

**Jeffreysia diaphana*, Alder.

Abundant on weed at low water at Porthwen (F.A.): one at Bull Bay (F.A.) and one at Puffin Is. (A.L.).

Skenea planorbis, Fab.

Porthwen at low water, and abundant near Pt. Erin (F.A.), always on seaweed.

Homalogyra atomus, Ph.

Sparingly near Port Erin and at Porthwen (F.A.): among *Laminaria* roots at Puffin (G.W.C.).

**Cæcum glabrum*, Mont.

Rare at Southport (C.H.B. and G.W.C.).

**Aclis unica*, Mont.
**Aclis ascaris*, Turton. } both rare at Southport (G.W.C.).

Aclis supranitida, S. Wood.

Dead records also from Bull Bay (F.A.); Crosby (A. Reade); central area, 2 specimens.

**Odostomia rissoides*, Hanley.

Abundant living at Puffin under stones and at *Laminaria* roots (A. Leicester): var. *dubia*, Jeff. (teste Jeffreys) Southport drift (C.H.B.).

**Odostomia pallida*, Mont.

One from Puffin Is. (G.W.C.).

[*Odostomia conoidea*, Broc.

"Isle of Man (Forbes, as *O. plicata* apparently)" Jeff. B.C IV, 128. An undetermined species dredged alive and dead in central area is probably to be referred here (F.A.).]

**Odostomia conspicua*, Alder., omitted in Rep. I.

"Douglas, I.M. (Alder)"—Jeff. l.c. 133, F. and H. III, 263.

**Odostomia dolioliformis*, Jeff.

Southport (W.H.H.).

**Odostomia decussata*, Mont.

One dredged at Port Erin (F.A.).

**Odostomia indistincta*, Mont.

Southport drift (C.H.B.), teste Jeffreys: do. frequent (G.W.C.).

var. *brevior*, Jeff. Southport (W.H.H.).

Odostomia rufa, Ph.

"Anglesea (McAndrew)" Jeff. l.c. 163.

var. *fulvocincta*, Thompson, c. dead in central area.

[*Odostomia pusilla*, Ph.

Douglas Bay, scarce in sand (Mal. Mon.): Southport, v. rare (C.H.B.). Looking at the published localities of this critical species, I am of opinion that these records require confirmation: it is so easily confused with *O. lactea* which is widely diffused in our district.]

**Odostomia scillæ*, Scacchi.

Central area, living and dead: new to district.

Eulima distorta, Desh.

Dredged at Fleetwood (W.H.H.).

Eulima subulata, Don.

c. at Crosby (A. Reade); several in central area and

20 m. W. of Southport: one at Pt. Erin (F.A.): not yet taken alive.

**Adeorbis subcarinatus*, Mont.

4 dredged dead at Bull Bay: one in central area ("Spindrift," 1890).

Velutina laevigata, Penn.

One dredged dead at Bull Bay, and young on seaweed at Porthwen (F.A.).

[*Cerithiopsis tubercularis*, Mont. "*C. tuberculata*" by error in Rep. I, p. 261.

Mr. Archer records 2 worn specimens, from the "Spindrift," 1890, as apparently belonging to this species. It therefore requires confirmation.]

Purpura lapillus, L.

A narrow elongated form occurs rarely at Llandudno (B.T.): an instructive comparison is to be drawn between the ordinary clean, well-coloured *Purpuras* so common at Llandudno by the pier, and a very large solid, muddy-looking form which occurs at extreme low water on the "Conway shore" (so-called) along the Morfa. By the pier shells of a rather unusual colour, pinkish mauve, are not uncommon.

var. *imbricata*, Lam. In the McAndrew Coll. (Camb. Univ. Mus. of Comp. Anatomy) may be seen a magnificent suite of some 40 specimens of this var., beautifully frilled. They were dredged in Rhoscolyn Bay, Anglesea, in 4—7 fms.

**Lachesis minima*, Mont.

Prestatyn, N. Wales (Grosvenor Mus., Chester).

Trophon truncatus, Ström.

c. young living in Bull Bay (F.A.): many dead off Tynygongl and in central area (F.A.).

[*Fusus islandicus*, Chem.

Of Forbes (Mal. Mon.) and C. H. Brown is of course

not the true *islandicus*,—a very rare species,—but =*gracilis*, DaC. The confusion has been general, cf. Jeff. B.C. IV, 334, sqq.]

Fusus gracilis, DaC.

Is found to be generally distributed in a live state: common in winter at Port Erin on the crab-pots (F.A.).

Fusus propinquus, Alder.

Llandulas Pt. (F.A.), Birkdale (G.W.C.), rare and dead only.

Nassa incrassata, Ström.

c. alive at Port Erin (F.A.).

Defrancia linearis, Mont.

One alive and several dead at Port Erin (F.A.).

**Pleurotoma costata*, Don., omitted from Rep. I.

Dead in 15—20 fms., N. Wales (Forbes).

Pleurotoma nebula, Mont.

Dead at Tynygongl and Bull Bay (F.A.), and at Southport extremely rare (G.W.C.).

Pleurotoma turricula, Mont.

Has now been dredged alive as follows:—central area: Bull Bay and Colwyn Bay (F.A.): c. 23 m. W. of Southport (G.W.C.).

**Utriculus truncatulus*, Brug., new to district.

Fleetwood (W.H.H.): Puffin Is., small specimens (G.W.C.).

Utriculus obtusus, Mort.

6 living at W. Kirby (F.A.), thus confirming Byerley's locality between Hilbre Is. and mainland (teste F. P. Marrat).

Scaphander lignarius, L.

2 living off Bradda Head, and taken also near Kitterland, Port Erin (F.A.).

**Philine punctata*, Clark.

One from roots of *Laminaria* on Puffin Is. (A. Leicester) : new to district.

**Philine nitida*, Jeff.

Two specimens off Southport in 12 fms. (J. T. Marshall).

Philine aperta, L.

Frequently dredged living near Tynygongl and in central area (F.A.) : 3 alive off Colwyn Bay (F.A.).

[*Aplysia depilans*, L.

According to Pennant, *Laplysia* (sic) *depilans* has been taken off Anglesea. Probably his species was the common *A. punctata*, Cuv.]

**Pleurobranchus plumula*, Mont., omitted from Rep. I. Isle of Man, F. and H. III, 561.

Pleurobranchus membranaceus, Mont.

A Fleetwood fisherman stated that this species is frequently fished up between Walney Is. and N. of Man especially about Easter, and that they are called "lumps of pork" : one specimen received thence by W.H.H. Shore, Bay-ny-Carrickey (W. A. Herdman).

Pulmonobranchiata.

**Melampus bidentatus*, Mont.

One at Port Erin (F.A.).

Otina otis, Turton.

R.D.D. is under the impression that Dr. Alcock and he many years ago got this species on stones at the foot of the lighthouse at the entrance to Channel at Fleetwood.

Cephalopoda.

**Spirula peronii*, Lam.

One or two authentic fragments of this species were

presented to the Grosvenor Museum, Chester, by a lady, with a lot of other ordinary beach shells,—all gathered at Rhyl.

[NOTE.—The Mollusca of the future L.M.B.C. expeditions will be worked up and reported upon by Mr. Alfred Leicester, Priory Gardens, Birkdale, who will gladly receive and acknowledge records of specimens from other conchologists in the district. Ed. L.M.B.C. Reports.]

On the AFFINITIES, INTER-RELATIONSHIPS, and SYSTEMATIC POSITION of the MARSIPOBRANCHII.

By G. B. Howes, F.L.S., F.Z.S.,
ASSISTANT PROFESSOR OF ZOOLOGY, ROYAL COLLEGE OF SCIENCE, LONDON.

With Plates VIII, IX and X.

[Read November 13th, 1891.]

I. The Lampreys (*Petromyzontidæ*) and Hags (*Myxinidæ*) have been classed together by Johannes Müller as the *Cyclostomata*,* by Prince Bonaparte† as the *Marsipobranchii*, and by Huxley‡ as the *Myzichthyes*. They have been defined by Günther§ as animals "without real jaws," while Beard (following Dohrn, and having discovered in them the existence of vestigial calcified teeth) concludes‖ that they "must undoubtedly be added to the gnathostomatous vertebrata." These citations, although by no means exhausting the alternative views current concerning their affinities, sufficiently testify to the existence of conflicting authoritative opinions, and justify a further enquiry into the facts upon which these are based. Choice between them must needs depend upon what is understood by a "jaw" and a "gnathostomatous vertebrate," respectively.

* Abhandlg. d. König. Akad, Wiss. Berlin, 1834, p. 76 (=the classical "Myxinoiden").

† Synopsis Vertebr. Systematis. Romæ, 1837, p. 25.

‡ Proc. Zool. Soc. Lond., 1880, p. 660.

§ Introd. to Study of Fishes, 1880, p. 691.

‖ Spengel's Zoolog. Jahrb. (Morph. Abth.) Bd. III, p. 747.

II. Huxley, in a classical monograph on the subject, has shown* that the sub-ocular skeletal arch (Pl. IX fig. 1 *p.q.*) and the cartilages which he terms the "postero-lateral" ones (*l.*) (the "Zweite Seitenplatte" of Joh. Müller)† answer in all essential respects to the parts of the cartilaginous mandibular arch of other vertebrata; and he showed that these parts, together with those which support the sucking mouth of the adult Lamprey and of the Anuran Tadpole, admit of a detailed comparison, except (p. 423) for the presumed absence in the former of an external maxillary ramus to the trigeminal nerve. He subsequently discovered the existence of this,‡ and thus proved that at any rate the Petromyzontoid family of the Marsipobranchii is a jaw-bearing one.

The term "gnathostomata" is used indifferently, to express either the mere possession of jaws, apart from any consideration of teeth, or (and more generally) that of a dentigerous jaw apparatus. If the former definition be accepted, the Marsipobranchii must stand as gnathostomata; and if the latter, the mere absence of calcified teeth in the adult will not justify their removal from the gnathostomatous series, so long as forms like the Sturgeon, in which a similar modification is realized, are retained therein.

III. The lowest living Sturiones (*Polyodon*) retain their teeth for life. The researches of Knoch§ and Parker‖ have revealed the existence of formidable teeth on the larval jaws of *Acipenser ruthenus*. Seeing, therefore, that the calcified teeth of the higher Sturiones wholly disappear

* Jour. Anat. and Phys. Vol. X, p. 412.

† Loc. cit., p. 174.

‡ Phil. Trans., 1883, pp. 414—415. It had been contemporaneously described by Fürbringer in 1875 (Jenaisch. Zeitschr. Bd. IX, pp. 62—67).

§ Bull. Soc. Imp. des Nat. Moscou. T. xliv, p. 281, 1871.

‖ Phil. Trans., 1882, p. 154, Pl. XIV, figs. 5, 6.

during ontogeny, and that those of the Marsipobranchii are replaced in horny successors, it is imperative to enquire whether the vanishing teeth are in the two types homologous.

The calcified teeth discovered by Beard in the Marsipobranchii lie, in all cases, beneath the familiar horny ones. Behrend has supplemented Beard's account of these structures in some details, and has recorded* his inability to discover that "enamel cap" described by him; and I personally doubt the very densely calcified nature of the teeth, upon which Beard lays stress. That which is most conspicuous however about these structures is their remoteness from both the jaw apparatus and all parts such as could conceivably represent that; wherefore it is highly improbable that they answer to the actual maxillo-mandibular teeth of the higher gnathostomata.

That the calcified teeth of the vertebrata are but inturned (mouth) scutes is certain; and in many Selachians (ex. *Cestracion, Carcharias)* nearly the whole of that part of the stomodæal membrane which does not invest the jaws is beset† (Pl. X, fig. 7) by a series of smaller scutes. These are for the most part unrepresented in the higher vertebrata; but the presence of a uniformly diffused series of minute denticles over the inner faces of certain bones bounding the mouths of some of the higher fishes (ex. the palatines, pterygoids, and splenials of *Amia*),‡ in the light of Hertwig's observations§ concerning the origin of the vomer, palatine and operculare (splenial) of the

* Zoolog. Anzeiger, 1891, p. 86.

†Conjointly with more or less of the pharyngeal (gill bearing) region. The presence of calcified denticles in the latter area is strongly suggestive of an inward proliferation of the epiblast, such as Beard has invoked in seeking to explain (Spengel's Zoolog. Jahrb, Bd. cit., p. 764) the origin of the taste buds.

‡cf. also Günther "Study of Fishes," p. 124.

§Archv. f. Mikr. Anat, Bd. XI, p. 108 (supplem.).

Axolotl and Salamander, by fusion of teeth alone,* and of his description of the part played by the teeth in determining the characters and limitations of certain other bones of the head, suggests that their restriction to and disappearance over a definitely localized area may have had originally to do with the first differentiation of the bony jaw-apparatus. Be this as it may, comparison of the Marsipobranch with the Sharks named, shows the calcified teeth of the former to be more nearly homologous with the said diffused denticles, than with those more superficial ones surmounting the jaws, which become of increasing importance in the ascending series of the vertebrata and alone remain in the highest members thereof. The inherent properties of the stomodæum are such that there is no apparent reason why it should not give rise to mouth scutes at all points; and, this being so, the differences between the calcified teeth of the Marsipobranchii and higher gnathostomata would appear to be expressive of complete divergence in modification from a common type. In the former the buccal scutes are restricted to the roof and floor of the mouth; in the latter they predominate in relation and are ultimately restricted to the jaws. †

The Marsipobranchii may be thus justly regarded as aberrant gnathostomata; but the facts herein stated necessitate a modification in the belief of Dohrn and Beard that they are descendants of relatively highly organized fishes (as judged by the structure of those extant).

* On examination of the advanced larva of *S. maculosa* I incline strongly to the belief that true bone is added at a late period.

† Parker's assertion (Phil. Trans., 1882, p. 154) that the developing bones of the larval Sturgeon's mouth are mostly dentigerous, and Ryders recent declaration (Bull. U.S. Fish Comm. Vol. VIII, p. 263) that minute teeth are present on its pharyngeal floor, render it highly probable that a diffuse-toothed stage is passed through by that animal.

IV. Admitting the Marsipobranchii to have had a gnathostomous ancestry, it is next incumbent to enquire with which of the living fishes they are most nearly allied.

I have elsewhere* attempted to homologize the pori genitales of the Marsipobranchii with the corresponding structures of the females of certain bony fishes in which the genital ducts have disappeared; and have pointed out that the urinogenital system of the Lampreys and Hags may be most satisfactorily compared with that of the Teleostei, the characteristic features in the two being an entire absence of all connection between the testis and kidney (euthorchidic condition) and the more or less complete suppression of the genital ducts, such as occur in no other living vertebrata. I have been further led to consider the genital ducts in both sexes of the Teleostei as distinct *sui generis* from those of the remaining gnathostomata, and to regard the urinogenital system of Teleosteans and Marsipobranchs as the least modified survivals of an hermaphroditic apparatus possessed by the ancestors of the vertebrata.†

* Jour. Linn. Soc. Lond. Zool., vol. XXIII, p. 551 *et seq.*

† Apropos of Cunningham's original observations (Qu. Jour. Micr. Sci., vol. XXVII, n.s., p. 49) on hermaphroditism in the Hag (*Myxine glutinosa*), Retzius, in criticizing the same, has pointed out (Biol. Förening. Förhandlg. Stockholm, Bd. I, p. 25, 1888) after the systematic examination of hundreds of examples, that the truly hermaphoditic nature of the individual had not been fully established. Cunningham has in a recent paper described the movements of the spermatozoa (Qu. Jour. Micr. Sci., N.S., vol. XXXIII, p. 173), and with this the enquiry enters the experimental stage. He confesses (p. 170) to a failure to procure fertilized ova. As he makes no mention, either in the paper cited or in its immediate predecessor (Zool. Anz. 1891, p. 22) of Retzius' observations, in must be assumed that he overlooked them.

This is the more unfortunate, as the most important of them deal with the structure of the encapsulated ovum when apparently nearing extrusion, and would unmistakably have been of immediate service to him in his enquiry.

Belief in an intimate genetic relationship between the Marsipobranchii and Teleostei, which naturally follows upon this, receives support, as I have already intimated (*loc. cit.* p. 554) from the observations of others upon the urinary apparatus and brain of these fishes. And, if the supposed vestigial spiracular (hyoid) cleft of the Lamprey originally described by Huxley* really has the value which he, Scott, Parker, and Dohrn, have ascribed to it,† that structure will at least testify to a further parallelism in modification between (*i.e.* the impress of a common hereditary tendency upon) the two groups of animals—if, indeed, it will not still further emphasize the deduction abovenamed.

The publication of my own paper was closely followed by that of a very remarkable monograph by Semon‡ in which the Marsipobranchii (Cyclostomata) are regarded (p. 182) as having lost their genital ducts. Although I can neither accept that author's surmise§ that these fishes and the Teleostei have suffered a loss of connection between the kidneys and testis, nor his views concerning the homologies of the supposed ducts which have disappeared, I gladly welcome his conclusion. It moreover affords me no little satisfaction to find that, from the study of the genitalia of hermaphrodite Sparidæ and Percidæ, Hoek has independently arrived at conclusions in no slight degree similar to my own. He has proved the hermaphroditic condition to be the more common in the first named of the

* Jour. Anat. and Phys., Vol. X, p. 420.

† As distinguished from Julin, who regards the second gill cleft of the Ammocoete as the homologue of the hyobranchial one of Selachians. For collected references see Nestler, Arch. f. Naturgesch, 1890, Bd. 1, p. 81.

‡ Jenaische Zeitschr. Bd. XXVI, pp. 89—195.

§ (loc. cit. p. 178) based on a comparison with the Coecilian *Ichthyophis glutinosa*, cf. also note at the end of this paper (p. 144).

two orders, and he asserts* that in males of *Box boops* and *Pagellus erythrinus* having "no trace of an ovary," the "oviduct" is still present in the shape of a closed tube, around which "vasa efferentia" are arranged as is the case with hermaphrodite individuals of the allied species." He concludes "that the occurrence of this vestigial "oviduct" in individuals otherwise by no means bisexual, affords strong proof in favour of the interpretation that hermaphroditism was originally a commonly occurring phenomenon in the order Sparidæ; and also† that "in the hermaphroditism of fishes we have to deal not with an abnormal condition, making its appearence in few cases, but, rather, with one, which, for most members of a large section of these animals, is perfectly normal." While he sums up the shorter communication,‡ in which he controverts the conception of homology between the genital ducts of both sexes of Teleostei and those of other vertebrates, by saying that it is to him "extremely probable that those who endeavour to establish homologies for the outgoing ducts of Teleosteans will finally have to reckon with the hermaphrodite Percids and Sparids." More than this I, personally, could not have desired. It will, I trust, be admitted that the facts above cited are of primary importance; and that, notwithstanding the great advance in the skeletal anatomy of the bony fishes, the Marsipobranchii are to be referred to a nearer kinship with them than with all other fishes extant. And it is worthy of remark that if the Teleostean and Ganoidean types are inseparably related, as Huxley has so long insisted,§ the

* Staats Courant, June, 1890, pp. 1—4.

† Handelg. v. h. 3de Natuuren geneesk. Congres. Utrecht. April, 1891.

‡ Dr. Hoek informs me, by letter, that he is preparing an extensive work upon this subject.

§ cf. especially Proc. Zool. Soc., Lond., 1880, p. 661, and 1883, p. 139.

Sturiones, structurally and palæontologically carry the former back to some early ancestral type of extreme structural simplification, such as may well have possessed a still stronger Marsipobranch affinity.*

V. Since the appearance of Huxley's epoch-making monograph on the cranio-facial apparatus of the Lamprey, it has been universally recognized that the resemblance between this and that of the Anuran Tadpole are of a very close order. Balfour, as is well known, laid much stress† upon the development of a sucking-mouth in these and other gnathostomata, believing (loc. cit. p. 264) "that in the ancestral chordata the mouth had a more or less definitely suctorial character." The late Dr. W. K. Parker's monographs on the development of the skull teem with passages either implying or openly proclaiming belief in a Petromyzontoid ancestry for the Batrachia, such as is to-day largely accepted and taught.‡ Dohrn, criticizing Balfour's observations, has pointed out§ that the suctorial apparatus is not in all cases composed of homologous parts. The Parkerian conception that the Anura are "Marsipobranchs in their larval state" may be therefore reconsidered. Not the least formidable objections to this, at the outset, are the totally different characters and constitution of the "horny teeth" of the Anuran

* The inability of palæontologists to detect the remotest traces of paired fins in the *Ostracodermi* must not be overlooked here, cf. A. Smith Woodward, Brit. Mus. Cat. Fossil Fishes, Vol. II, p. xvii Introd., and pp. 159 and 176.

† Comp. Emb. Vol. II, pp. 263—264.

‡ cf. Phil. Trans., 1881, Part I, pp. 3, 24, and 30; 1883, Part II, p. 376 especially, and also pp. 417 and 451. It is worthy of remark that Huxley's dictum reads (Jour. Anat. and Phys., Vol. x, p. 427) "the cranio-facial apparatus of the Lamprey can be reduced to the same type as that of the higher vertebrata, by means of the intermediate terms afforded by the Tadpole's skull."

§ Naples Mittheil. Bd. v, pp. 104—105; cf., also Beard op. cit. p. 745.

tadpole* and Marsipobranch, and the entire absence not only of horny teeth and sucking mouth, but of larval metamorphosis, such as is exemplified by our common Frogs, in both the Urodela, and *Xenopus* (*Dactylethra*) the most completely aquatic Batrachian in existence.† On the Parkerian hypothesis this ought not to be so. These facts and numerous others akin to them, which have arisen during the recent study of metamorphosis and "nursing" among the amphibia and other Ichthyopsida,‡ point much more natually to the conclusion that the well known characters and provisional appendages of the larval Anura are, together with the various types of external gills formed among the Urodela, secondarily acquired and adaptive; and that the only structures conspicuous during metamorphosis at all recapitulatory in the sense implied, are the internal gills, with their associated skeletal and vascular arches,§ and the tail.

In the various publications dealing with the sucking mouth of the vertebrata, the extent to which that structure is represented among the living Chimæroids has been insufficiently recognised. The labial cartilages of *Callorhynchus* (fig. 5, Pl. X), as originally pointed out by Johannes Müller in his monumental "Myxinoiden" (*op. cit.*) attain a development unparalleled among the higher gnathostomata. While agreeing in their fundamental rela-

* See Schulze, Abhandl. Akad., Berlin, 1888. Héron Royer and Van Bambeke, Archv. d. Biol. Tm. IX, p. 185, and Gutzeit, Zeitschr. f. Wiss. Zool. Bd. XLIX, p. 43, cf. also Beard op. cit.

† cf. Leslie and Boulenger, Proc. Zool. Soc., Lond., 1890. p. 69.

‡ cf. Boulenger, Ann. and Mag. Nat Hist., Ser. v., Vol. XVII, p. 463; Ser. vi., Vol. I, p. 454, and Vol. II, p. 122; also Fletcher Proc. Linn. Soc. N.S.W., Ser. ii, Vol. IV, p. 357; and Wood Mason and Alcock Proc. R. Soc., Lond., Vol. XLIX, p. 359, and Vol. L, p. 202.

§ Approached from this standpoint the position of the *Dermatremata* in the Amphibian series receives a fresh significance.

tionships with the less numerous and less specialized ones of *Chimæra* and (through that genus) with those of certain Elasmobranchs, they admit of a comparision with the supports of the accessory buccal folds of the Myxinoids; and if, as I herein seek to show, (*infra*) they may be regarded as homologous with the main cartilages of the Lamprey's sucking lip, the resemblance between that structure and the well pronounced fold (*l. ac.*) of the antarctic Chimæroid becomes most striking.

I have elsewhere* emphasized the conclusion that the structure of the reproductive organs of the Amphibia and Holocephali and of the Marsipobranchii are referable to two totally distinct types; the facts upon which this argument is based, considered conjointly with those above alluded to, render it, to my mind, inconceivable that there can be any near relationship between Amphibians and Marsipobranchs, and, therefore, that the sucking-mouthed stage of the former (which is confined to certain Batrachian forms) can be anything but secondarily acquired. *Callorhynchus*, viewed from the same standpoint, would appear to furnish evidence, not only that the question "whether a sucking mouth be primitive or not" is to be decided in the negative,† but of an independent evolution in the Holocephali (*Callorhynchus*) and Marsipobranchii (Myxinidæ) of closely similar types thereof.

The chondrocranium of certain lower Urodela (ex. *Proteus*, *Menobranchus*), with its absence of so-called "occipital arch," with its nonfusion of the anterior ends of the trabeculæ and its widely open floor which accompanies this, with its independence of the pre-ocular (ant-

* *loc. cit.*, p. 556.

† Beard, *loc. cit.*, p. 746.

orbital) and pterygo-quadrate cartilages,* is, as Huxley first intimated,† more embryonic than that of the Lamprey. There is thus good reason for concluding that the higher Amphibia have reached the supposed Marsipobranch stage in the evolution of the skull, by an independent line of modification. The argument deduced from the study of the external gills and sucking mouth (*ante*, p. 130) applies here, and, in doing so, still further diminishes the force of that in favour of a Marsipobranch ancestry for the Anura.

VI. All recent enquiry into the morphology of the cranio-facial apparatus of the Marsipobranchs finds its focus in Huxley's monograph already cited, in which the presence of true jaws was first demonstrated and the complex apparatus of the Petromyzontidæ was brought into harmony with that of the higher gnathostomata. Huxley alluded to the Myxinoids but incidentally (op. cit. p. 428); Fürbinger‡ and Parker§ have however dealt more fully with their head skeleton from the modern standpoint. Neither author's description at all bears out Huxley's stray remark that "there is even less difficulty in reducing the skull to the ordinary vertebrate type"

* The fusion of these to form a complete sub-ocular arch, like that of the Batrachia, occurs only in *Ranodon* (Wiedersheim, Morph. Jhb., Bd. III, p. 425). The recent discovery by Riese (Spengel's Zoolog. Jahrb., Bd. V, [Morph. Abth.,] p. 114) of a quadrato-jugal bone in the Eastern *Tylotriton verrucosus*, raises the question whether the great reduction of the pterygo-quadrate cartilage of the majority of Urodeles may not be associated with that marked tendency towards suppression of the maxillo-jugal elements, so conspicuous in them?—a feature in which, as in the non realization of a type possessed of pentadactyle fore and hind limbs, the living Urodela show themselves to be more aberrant than the Anura.

† Proc. Zool. Soc., Lond., 1874, p. 193.

‡ Jenaische Zeitschr. Bd. IX, pp. 1—127, 1875.

§ Phil. Trans., 1883, pp. 373—453.

than with the Petromyzontidæ; and this, in view of certain of Parker's determinations having been based on subtle differences in histological structure of the cartilages themselves, is sufficient justification for reconsidering the question.*

Comparison of Fürbinger's and Parker's work with that of Huxley leaves little room for doubting the homology of the cartilages lettered *cn.* and *p.q.* in figs. 1 and 2, Pl. IX with the lateral cornu of the hyoid and the sub-ocular arch (palato quadrate) of the higher vertebrata; while the median rod which lies immediately beneath the Hag's olfactory organ recalls, in all its essential relationships, the expanded plate of the Lamprey (*p.d.* of figs.). The chondrocranium of the Hags is on either side elongated and laterally expanded, in relation to a freely movable cornu (*l.* fig. 2) which enters the adjacent tissues and was termed by Parker the "prepalatine" cartilage. In its relationships to the super ficial branches of the trigeminal nerve this "prepalatine" closely corresponds with that which Huxley claimed (loc. cit. p. 427) as Meckel's cartilage in the Lamprey, and with that I hold it to be homologous, notwithstanding Parker's view to the contrary.† If this be so, further comparison of the Lamprey and Anuran Tadpole shows that the quadrate articular element instead of being represented in the Myxinoids by a portion of the sub-ocular arch lying behind the orbit, as Parker supposed,‡ is in much greater likelihood included in the aforenamed elongated lobe (*qu.* of figs. 1 and 2) which lies in front of it. The marked forward disposition of the quadrate articulation

* Some critical remarks upon Parker's observations on the branchial skeleton will be found in Nestler's paper already quoted (ante. p. 127). This monograph deals satisfactorily with several more moot points in the anatomy and development of the Lamprey.

† *loc. cit.*, p. 452.

‡ *loc. cit* p. 378.

is a characteristic of the higher autostylic fishes (*Holocephali* and *Dipnoi*); and if the above determinations are correct, it must be regarded as a tendency, most marked in that type of skull, which the Myxinoids have carried to its greatest pitch, with an accompanying degeneration of the Meckelian element.

Both Fürbinger and Parker agree in refusing to homologize the great lingual cartilage of the Lamprey (Pl. IX, fig. 1, *p.v.*) with that much more extensive one in the Hags which, at first sight, it so fully resembles (fig. 2, *a.v.*). On comparing transverse sections across the heads of the Lamprey and Hag (*Bdellostoma*) the lingual cartilage of the former is seen to lie within the great muscular mass extending back towards the pericardium, while that referred to in the Hag occupies a superficial position ventrally. Moreover, not only is the latter free of the tongue, but that organ is supported by a delicate cartilage lying for the most part within the tendon of the central retractor muscle ("longitudinalis linguæ" of Fürbinger), asymmetrically displaced (fig. 4, *p.v.*) towards the right side. If, however, the sections be taken far enough forwards, it will be found that a small T shaped cartilage present in the Lamprey (*a.v.* figs. 1 and 3) (the "median ventral" of Huxley) has the fundamental relationships of the dominant monster of the Hag; and, partly for this reason, partly for others given below (p. 137) I regard these as homologous. On doing this, I can only look upon the slender chondrification lying within the tendon above named as the equivalent of the main support of the Lamprey's tongue; and reflection leads me to the conclusion that the median ventral cartilages of the two types are reducible to the same plan, but inversely modified in the one animal as compared with the other. If, as can hardly be doubted, the "tongue" of the Marsipobranchii is an organ peculiar

to them and unrepresented in the higher vertebrata, the question how far the abovenamed median ventral cartilages may be comparable to the basi-mandibulo-hyo-branchials of the latter, as Müller, Huxley, and Parker, have together sought to show, must remain in abeyance, until more is known of the development of these fishes. The safest course for the present lies in regarding them as peculiar to the Marsipobranchii, especially if Fürbinger's assertion* that a corresponding tract at the base of the tongue may be ligamentous in *Myxine* altho' invariably chondrified in *Bdellostoma* shall prove correct.

The greatest difficulty arises in dealing with those parts which in the Myxinidæ support the peri-oral folds, with their derivative tentacles. The most satisfactory description of them is the classical one of Joh. Müller. Neither Fürbinger nor Parker dealt with them in detail, and the latter author finally concluded (Phil. Trans. 1883, p. 404) that they were "merely barbels," refusing to admit them "perfect labial cartilages." They are usually five in number on either side. One (*l*), borne upon the basi-ethmoidal rod may be dismissed as probably distinct from the rest. Of the four which remain one (*lb.* i) supports the dorsal tentacle; a second (*lb.* iii) enters the lateral one; a third (*lb.* iv) lies within a fleshy fold below the mouth; while the fourth (*lb.* ii) is T shaped, sending in a rod or process which abuts against the main cartilaginous supports for the lateral head region.† In the Lamprey the sucking-mouth is mainly supported by the great annular

* *loc. cit.*, p. 8.

† This "rod or process" may or may not be an independently distinct element, in individual specimens of both *Myxine* and *Bdellostoma* (cf. figs. 2 and 6). It is apparently that referred to by Fürbinger (cf. *supra*) as fibrous in the firstnamed genus. In all examples which I have examined it is densely chondrified, altho' in one of them it partook of the nature of the "soft cartilage" of W. K. Parker.

cartilage (Pl. IX, fig. 1, *an.*) and its paired cornual appendage (*v.e.*); and at first sight the more numerous and delicate structures met with in the Hags, present nothing in common with these, except for their approximate arrangement in an annular series.

Returning now to *Callorhynchus* (in which, as already seen, [ante. p. 131] a considerable lip akin to the Lamprey's suctorial one is developed), no inconsiderable similarity suggests itself, on comparing its labial cartilages with the structures which in the Lamprey and Hag appear so entirely different. The labials of *Callorhynchus* (Pl. X, fig. 5) are usually nine in number on either side. The leading one (*lb.* ix), which is so immense as to be little short of the mandible in functional importance, suggests that of the Hag (*lb.* iv, fig. 2) but for its complete confluence with its fellow in the mid ventral line;* in respect to this, and to the extent to which it supports the lip, it no less obviously recalls the lower half of the Lamprey's annulus, while its prolongation downwards and backwards among the sub-dermal tissues suggests that it at least functionally represents the cornual appendages of that also. Among those cartilages which remain, the inwardly directed element (*lb.* v) suggests, in a similar manner, the base of the T shaped piece of *Bdellostoma*, which may be distinct; both lie above the mouth, and they differ most conspicuously in the fact that whereas that of the Hag stops short of the olfactory region, that of the Chimæroid reaches it.

Chief among the remaining pieces in the Hag are six (the "basihyals" of Parker) all lying closely approximate to each other and to the great antero-ventral cartilage (*av.* fig. 2), the series forming a kind of bed for the expanded tooth-bearing "tongue." The two posterior of these (*cn.*)

* On examination of a young *Callorhynchus* of 130 mm. total length I find this to be represented by two distinct cartilages as in the Hag.

meet in the middle line below, and their relationships to the "styliform processes" (*st.*) are so closely identical with those of the "cornual cartilages" in the Lamprey, (*cn.*) except for the confluence between the two, that the homology with them can hardly be doubted. Of the four anterior ones, the outer two (*v.e.* fig. 2) are, as Joh. Müller showed, intimately connected with the lip supports, through the mediation of the afore described T piece, while the inner pair (*v.i.*) lie closely related to the anterior extremity of the great lingual (antero-ventral) cartilage (*a.v.*). Comparison with the Lamprey is here most suggestive, for the insignificant antero-ventral element of that animal (fig. 1, *a.v.*) bears a couple of upstanding rods (*v.i.*) having very much the same relations as these; while, in their intimacy with the lip supports and their relationships to the descending branches of the trigeminal nerve the outer pair resemble very closely the cornual appendages (*v.e.*) of that animal's annulus. These three pairs of cartilages if homologous, as I herein attempt to show and fully believe, are to no slight degree inversely proportionate in size and functional importance in the Lamprey and Hag, and I am strongly disposed to seek the clue to this difference, in changes which have led up to that similar disproportion in the median lingual elements of the two types, already alluded to (*ante.* p. 134).

In discussing the inter-relationships of the Lampreys and Hags, Huxley* and others have regarded the former as the more primitive, while Parker,† Beard,‡ and others have reversed the order. That the *Bdellostoma*, with its independent gill openings in the condition of the Lamprey's, and its head skeleton and olfactory apparatus in

* Jour. Anat. Phys. Vol. X, p. 428.

† Phil. Trans., 1883, p. 417.

‡ Zoolog. Jahrb., cit., p. 742, cf., also Anat. Anz., 1885, pp. 15—24.

that of the Hag's, is a satisfactory transition type, has long been recognised. From the study of the olfactory organ and its associated parts (infra p. 142) I entirely agree with Huxley's belief. Concerning the comparison which I herein institute between the less numerous cartilages which support the Lamprey's sucking mouth, and the more numerous ones, having essentially the same relationships, in the Hags and *Callorhynchus*, the only course open, in the absence of observations upon the development of the latter animals, is to enquire if argument from structural analogy will or will not bear this out? I would direct attention to the ossification of the hypo-hyal of the Teleostei from two centres instead of one as elsewhere—to the inconstancy in number and relationships of the ossific centres of the body of the hyoid generally,*—to the great variability in number and disposition of the splenial elements of the mandible—to the great variation in number and relationships of the labial cartilages of Elasmobranchs†—and, more especially, to the fact that whereas in *Polyodon*‡ the palato quadrate cartilages are simple, and remote except for their symphysial anterior borders, being altogether normal in character, in the allied Acipenseroids they meet above the roof of the mouth, and become secondarily fragmented in a manner as unparalleled as it is extraordinary.§

The above cited facts appear to me to answer the question in the affirmative. There are involved in a comparison of the palatoquadrates of the Sturiones just

* cf. espec. the Batrachia, Parker, Phil. Trans., 1881, part I.

† I have often wondered that in *Rhina* (*Squatina*), where these simulate the arrangement of the mandibular arch and hyomandibular they have not been claimed by some ingenious person as a corresponding pre-oral series.

‡ cf. Bridge. Phil. Trans., 1878, pp. 701—702, and Pl. 57.

§ Parker and Howes, Phil. Trans., 1882, p. 117.

alluded to, differences far greater and more remarkable than those between the lip supports of the Lamprey and Hag; and I am therefore constrained to regard the series of slender cartilages which in the Myxinoids support the lip (*lb.* i—iv fig. 2) as together equivalent to the Lamprey's annulus, and (with Joh. Müller) as comparable to the labials of Elasmobranchs, regarding the differences between the two types as either due to divergence in functional modification or to degeneration upon the reduction of the sucking mouth.* If this be conceded, there is demonstrated a very marked structural unity between the Petromyzontidæ and Myxinidæ, in respect to which they hold together as clearly as, in the absence of paired fins at all periods of life,† and in other well known features, they stand apart from the remaining vertebrata. Their interrelationships admit of a ready comparison with those of the existing Monotremes, except that in the latter there is no counterpart for the *Bdellostoma* type.

VII. That the general organization of the Marsipobranchs is a simplification of that of the higher vertebrata has long been recognized. The position of the heart, the structure of the kidney, the alternation of the roots and distribution of the spinal nerves (*Petromyzon*), are conspicuous characters concerning which these animals, as compared with the higher gnathostomata, are in a persistently embryonic condition. While this is so, the study of the hypophysis shows them to be modified in a direction altogether away from the other vertebrata. Despite the deal that has been written upon this organ, the signi-

* Parker's failure to discover a complex origin for the Lamprey's annulus (Phil. Trans., 1883, p. 422) strengthens the latter view.

† Dohrn's alleged discovery (Naples Mittheilg, Bd. VI, pp. 406 *et seq*) of a pelvic-fin rudiment in *Petromyzon* appears to me to rest upon a wholly insufficient foundation.

ficance of the facts of its morphology has not yet received that emphasis which it deserves.

The oral hypophysis (pituitary body) is well known to arise in the higher vertebrata as a diverticulum of the stomodæum; and as such it is customarily described. Goette described it in 1874* as having, in *Bombinator*, a provisional connection with the olfactory organ, and he therefore homologized it with the naso-palatine duct of the Marsipobranchs. Dohrn, eight years later, while extending this view of the homology of the pituitary body, discovered† its primary independence in origin from the epiblast, and in so doing opened up a new era in its study. Comparison of Goette's and Dohrn's figures leaves little room for doubting the homology of the structures which they described. Scott has raised objections to Dohrn's views, upon the grounds that‡ "there is no more reason for regarding the entire canal of Cyclostomata as belonging to the hypophysis than in the case of the higher vertebrates for regarding the entire stomodæum as belonging to that body." This objection is to-day invalid, inasmuch as all subsequent research has proved that the said "entire canal" of the Cyclostomata is the homologue of that from which, by modification consequent upon its being carried in with the stomodæum, the pituitary body of all the higher gnathostomata is derived.§ Scott has further laid stress‖ upon the fact that the connection described by Goette between the olfactory organ and the hypophysis of the Fire Toad could not be found in any other Amphibian whose development had been then investigated. All sub-

* Entwickelungsgesch, d. Unke., p. 318.

† Naples Mittheilungen, Bd. IV, p. 172.

‡ Jour. of Morph. Vol. I, p. 267.

§ see Kaeennsche in Schneider's Zoolog. Beiträge, Breslau, Bd. II, pp. 228—229. 1890.

‖ Loc. cit., p. 267.

sequent inquiry has borne this out; so much so, as to have rendered it very doubtful if Goette was not mistaken; and, in doing this, it has but the more fully confirmed and extended Dohrn's epoch-making observation (except so far as that author would regard the hypophysis as a pair of preoral gill-pouches).* Indeed, Scott himself has undoubtedly erred, from failure to sufficiently appreciate this absolutely independent origin of the structure in question.

All observers are agreed that the pituitary body is a vestigial organ, probably inherited from an ancestor unknown; and the facts of development to-day recorded, while leaving little room for doubting its primary independence of both mouth and nose, show that whereas in all the higher gnathostomata it is carried down with the stomodæal involution, perforating the basis cranii from beneath, in the Marsipobranchii it is carried up with the olfactory apparatus, perforating the cranium from above. This consideration is in no way effected by any possibilities concerning the homologies and original functions of the organ. In view of the admitted importance of that, it testifies, to my mind, to an enormity in the gap between the Marsipobranchii and the remaining higher vertebrata, which even Balfour's conclusion† that the former are "the remnants of a primitive group," and Hæckel's famous aphorism‡ that "they are further removed from the fishes than are the fishes from man" insufficiently express.§ It disposes of attempts to prove that "connecting links" between the Marsipobranchii

* Naples Mittheilungen. Bd. III, p. 264.

† Comp. Embryology. Vol. II, p. 69.

‡ "Anthropogenie," p. 425.

§ It finds its nearest expression hitherto formulated in Hæckel's subdivision of the gnathostomata into Monorhina (Marsipobranchii) and Amphirhina.

and the higher vertebrata are known to us; and it is, to me, a question whether it does not warrant a greater than a class distinction, viz., the subdivision of the subkingdom vertebrata into two lesser kingdoms, the one (*Epicraniata*) for the reception of the Marsipobranchii alone—the other (*Hypocraniata*) for that of all the higher forms, in the manner expressed in the appended table (Plate VIII).

VIII. Dohrn's researches have further established the fact* that the growth of the Lamprey's sucking lip chiefly involves the tissues lying between the hypophysial and oral involutions; and they therein suggest a determining cause for the upward displacement of the former, and its secondary association with the olfactory organ. If this be admitted, two important conclusions follow as a logical sequence, if the homologies which I have herein sought to establish are correct, viz., (*a*) that the position and relationships of the parts about the mouth of the Myxinidæ presuppose the existence in their ancestors of a sucking lip of the Petromyzontoid type, and (*b*) that the sucking mouth of the higher vertebrata, in chiefly involving the tissues between the hypophysial and olfactory involutions, can have little primarily to do with that of the Marsipobranchs—a deduction which once more undermines the notion that the Amphibian Tadpole is recapitulatory of a Marsipobranch stage in phylogeny.†

To turn, finally, to the consideration of the belief in the marked structural unity of the Marsipobranchii (ante. p. 139). Comparison of the Lampreys and Hags proves, beyond doubt, that the dominating structure in their joint

* Naples Mittheilungen. Bd. IV, pp, 177—178.

† The doctrine of the late Dr. Anton Schneider ("Zoolog. Beiträge" Bd. II, p. 102) that "the Petromyzontidæ are cyclostome fishes, the Myxinidæ possibly cyclostome amphibians" may, I trust, be allowed to sink into oblivion.

organization is not so much the sucking lip, as is most frequently supposed, but the rasping tongue?* The more salient structural pecularities of the heads of these animals may be read off in relation to this, as may be those of the Lamellibranchiate mollusca, for example, in relation to the absence of the head itself. And, moreover, the fact that the common lampern "consumes water insects and the flesh of dead fish"† and that of the regular capture of Hags on the long-line hooks, go far towards suggesting that the extent to which a parasitic habit may have induced these peculiarities has been grossly over-estimated.

IX. The palæontological history of the Marsipobranchii, until lately estimated upon the supposition that the Conodonts, some of which have been claimed as annelid jaws,‡ are Marsipobranch teeth, has recently undergone a revolution, in Traquair's description§ of a very remarkable fossil from the Old Red Sandstone at Caithness, which he has named *Palæospondylus gunnii*, after its discoverer. In his preliminary paper he remarks (p. 485) on the presence of "vertebral centra" which are "hollow or ring-like" and states (p. 486) that "a Myxinoid with ossified skeleton . . . is a rather startling idea." From careful examination of a duplicate specimen which Dr. Traquair has very generously given me, I fully acquiesce in his having provisionally referred the creature to a Marsipobranch affinity, and look upon the noto-

* Parker has already proclaimed this for the Myxinidæ (Phil. Trans., 1883, pp. 381 and 382).

† Francis Day, in Fish. Exhib. literature. London, 1884. Vol. VIII, p. 326.

‡ Rohon and Zittel, Sitzungsb. d. k. bayerisch, Akad, 1886, p. 108. Dr. G. J. Hinde, who has paid considerable attention to these structures (cf. Qu. Jour. Geol. Soc., vol. 35, p. 370) informs me by letter that he has "no doubt of the complete distinctness" of the two.

chordal ossifications as most nearly suggestive of the calcified annuli of the living Chimæroids. There appears to me no inherent objection to referring the animal to a kinship with the Hags, merely because its skeleton was superficially calcified, especially if Dohrn's views of the origin of Cyclostomata by degradation from a truly gnathostomatous type, and if Walcott's recently alleged discovery of a Chimæroid notochord in the Ordovician strata,* should ultimately prove correct.

X. *Note on the table* (Plate VIII). The accompanying table† is intended to give expression to the views advocated both in this paper and an earlier one.‡ In the latter I defined the Euthorchidic vertebrata as those in which "vasa efferentia are unrepresented, and the Wolffian or segmental duct is exclusively renal in function" where it exists; regarding the Nephrorchidic forms as those in which "vasa efferentia are present and the excretory organ is an accessory to reproduction in the male," and referring the Ganoids, together with the Teleosteans and Marsipobranchs, to the first named series. Its publication immediately preceded that of two important papers bearing upon the subject in hand. One, by Ryder,§ containing much that is valuable concerning the natural history of the Sturgeons, but adding little to our knowledge of their genitalia; the other by Semon,‖ confirming Balfour and Parker's description¶ of vasa efferentia in *Lepidosteus*, and

* Bull. Geol. Soc., America. Vol. III, p. 165.

† In the table "Ganoidei? all" is intended to exclude the living Crossopterygii (*Polypterus* and *Calamoichthys*) pending a sufficient knowledge of their reproductive organs. cf. Semon *op. cit.*, p. 634 and Traquair Proc. R. S. Edinb., vol. v., p. 659, 1865—66.

‡ Jour. Linn. Soc. Lond. Zool. Vol. XXIII, p. 556, 1891.

§ Bull. U.S. Fish Comm. Vol. VIII for 1888, p. 231,

‖ Morph. Jahrb. Bd. 17, p. 623.

¶ Phil. Trans., 1882, p. 413.

extending that observation to the Sturgeon and perhaps to *Amia* (with a correction of Rathke's original remarks* concerning the former of these two animals). While I gladly accept this definite contribution to knowledge, I fail to see that it necessarily implies the derivation of the genital system of the living Ganoids and Teleosteans from that of the Elasmobranchs, with loss of connection between the testis and kidney, as believed by Semon.† His observations necessitate the provisional relegation of the Ganoids to the opposite series to which I assigned them, and demand a reconsideration of my surmise "that the formation of the Müllerian duct must have preceded that of the vas deferens" (p. 556). Beyond these points, I remain adherent to the views expressed in my earlier communication.

Explanation of the Plates.

Plate VIII.

Table indicating certain structural relationships of the living Ichthyopsida. (see p. 144).

Plate IX.

Figs. 1, 2, and 5, are intended to indicate the homologies of the labial, mandibular, and hyoid-arch systems of *Petromyzon*, *Bdellostoma*, and *Callorhynchus*, as determined in the text. The obliquely-lined areas represent the labial and allied superficial cartilages; the stippled ones the parts of the mandibular and hyoid arches.

* Schriften der Naturf. Gesellsch. Danzig. Bd. I, 1824.

† cf. my former paper cited p. 555.

The velar skeleton and the cartilaginous supports for the apex of the tongue are, for simplicity's sake, omitted in all the figures.

Fig. 1. Outline sketch of the head of *Petromyzon marinus*, dissected to the level of the great cartilages. The branchial cartilages, together with those which support the velum and lingual teeth, are omitted. *Nat. size.*

Fig. 2. Outline sketch of the corresponding parts of *Bdellostoma Forsteri*. The antero-ventral cartilage (*a.v.*) is represented as dissected to the level of the longitudinalis-linguæ muscle, with its enclosed postero-ventral cartilage (*p.v.*), the forward course of which is represented by the dotted line *x*. $1\frac{1}{3}$ *nat. size.*

Fig. 3. *Petromyzon marinus*. Transverse section to show the relationships of the median ventral cartilages to the lingual muscles. Taken across the line α β of fig. 1. *Nat. size.*

Fig. 4. *Bdellostoma Forsteri*. Corresponding section to fig. 3. Taken across the line α β of fig. 2. $1\frac{1}{3}$ *nat. size.*

The blackened areas in this and the preceding figure represent blood-lymph spaces.

Plate X.

Fig. 5. Dissection of cranium, with the labial and mandibular-arch cartilages, of *Callorhynchus antarcticus*; male, serial with figs. 1 and 2. *Nat. size.*

Fig. 6. The labial cartilages of *Bdellostoma Forsteri*, enlarged, for comparison with those of *Callorhynchus*. The specimen was exceptional, for the independence of the element lettered *lb.v.* *Twice nat. size.* The lettering adopted in this

figure indicates the superficial resemblances between the labial cartilages of the two genera abovenamed. *Nat. size.*

Fig. 7. Median longitudinal section of the head of *Cestracion* (*? sp.*). The coarsely stippled areas represent those of development of diffuse buccal scutes.

Reference Letters.

The terms employed in dealing with the cartilages are a modification of those of Huxley (Jour. Anat. and Phys. Vol. X, pp. 412—428); the chief alterations being the addition of *ventro-external*, and the substitution of *antero-ventral*, *lateral*, *postero-ventral*, and *ventro-internal*, for his "median ventral," "postero-lateral," "lingual," and "antero-lateral."

a.d. antero-dorsal cartilage; *au.* auditory capsule; *an.* annular cartilage; *a.v.* antero-ventral cartilage; *b.s'.* basi hyoid cartilage; *b.s''.* basi branchial cartilage; *c.c.* cephalic clasper; *ch.* notochord; *cl'.* spiracular gill cleft; *cl''.* first branchial cleft; *cl'''.* second branchial cleft; *cn.* cornual cartilage; *co.* œsophageal cœcum; *cr.* cranium; *cr'.* cranial roof; *cr''.* basis cranii; *l.* lateral (Meckel's) cartilage; *lb* i to ix. labial cartilages; *m.* mouth; *mc.* Meckel's cartilage; *m.l'.* superficial lingual muscles; *m.l''.* deep lingual muscles; *my.* myelon; *œ.* œsophagus; *p.d.* posterior-dorsal cartilage; *p.q.* subocular arch (palato-quadrate cartilage); *p.v.* postero-ventral cartilage; *qu.* quadrate lobe of sub-ocular arch; *st.* styliform process; *v.e.* ventro-external cartilage; *v.i.* ventro-internal cartilage.

The ELECTRIC ORGANS of FISHES.

By Francis Gotch, M.A., F.R.S.,

PROFESSOR OF PHYSIOLOGY IN UNIVERSITY COLLEGE, LIVERPOOL.

(Abstract.)

Professor Gotch prefaced his remarks with a brief historical retrospect indicating the extent to which the powers of electric fish were known to the ancients and the various explanations which were advanced to account for them. He then referred to the experiments of Walsh in 1773 which first showed that the extraordinary effects produced by the Torpedo were in reality due to the production in a special organ of the animal of a powerful electrical discharge. The fish thus was shown to possess a structure which could at will be turned into a powerful electric battery.

In order to study the mode of formation, structure and functional powers of this electrical organ, he directed the attention of the audience to four different fish:

(1) *Torpedo*: a flat fish closely allied to the family of the Skates and Rays, often termed the electric Ray: inhabiting the sea in low latitudes.

(2) *Gymnotus* or Electric Eel: inhabiting the branches of the River Orinoco in S. America.

(3) *Malapterurus*, one of the Siluridæ, known as the Thunder-fish: inhabiting the branches of the Nile, Congo, Senegal and other rivers of Africa.

(4) *Raia batis*, &c., the common Skate.

* Part of a Lecture delivered before the Biological Society, 13th May, 1892.

The essential features of an electric organ as such were described in more detail in the case of the Torpedo, and the distinguishing characters of the organ in each of these representative fish were then alluded to.

(1) *Torpedo.* This fish has two electric organs, one being situated on each side in the lateral mass of muscles external to the gills. Each organ is composed of a series of hexagonal prismatic columns arranged side by side, the base of each column resting on the ventral skin whilst its summit is covered by the thicker dorsal skin. The number of these columns varies in different species from 300 to over 1000; but it is constant in any one species, and is the same in the young as in the adult stage of the fish, the columns growing in size but not increasing in number with the growth of the creature. In a very fine specimen, measuring $3\frac{1}{2}$ feet from head to tail, which was shown to the audience and was given to the Zoological Museum of University College by the Curator of the Public Museum, the number of columns in each organ was 976; probably the species was the Atlantic *T. hebetans* (the *T. nobiliana* of older writers). Each column in its turn consists of a series of over 500 superimposed plates or discs, separated from one another by an albuminous liquid, and arranged transversely to the length of the column, the whole thus resembling in structure the Voltaic pile so familiar to students of electricity. In each organ the columns are very richly supplied with separate nerves which enter and end in the plates; they are derived from four very large nerve trunks, and these emerge from a special mass of nerve cells on the dorsal aspect of the medulla oblongata, which is known as the electrical lobe.

By the nervous activity of this electrical lobe the fish is able to transmit down the nerves to the plates of the columns in the organ, nervous impulses in precisely the

same way as it is able to transmit such impulses to its muscles. In the case of the muscles the arrival of the nervous inpulse is followed by a contraction or movement in each muscle fibre, whereas in that of the electrical organ the arrival is signalised by the production in each plate of every column of an electrical effect; and since in the columns a very large number of plates are simultaneously the seat of this electrical change, the total effect in the whole organ is to produce an electrical current of considerable intensity, which flows through the organ from the ventral to the dorsal surface of each column, the circuit being completed by the salt-water and surrounding tissues.

The greater the number of columns and plates the greater will be the intensity of the electrical effect, provided that the nervous impulse which starts it remains at the same pitch of intensity. If only one group of nervous impulses travel from the brain to the organ, a single electrical effect in the columns of very short duration (only $\frac{1}{100} - \frac{2}{100}$ second) is produced, and the effect of this upon such an object as a man's hand placed upon the fish is precisely like that produced by one electrical shock. It is therefore termed the "shock" of the organ.

The fish has however the power of discharging a second and third group of nervous impulses, and may discharge several hundreds of such groups, following one another at the rate of one hundred per second. The physiological effect of this is very considerable, numbing the hand placed on the fish: it resembles that caused by the successive series of electrical shocks discharged from a magneto-electric machine. Such a succession of shocks is the normal response of the animal to irritation, and is called a "discharge." As the power to send these rapidly following shocks is dependent upon the functional activity of the

central nervous system, the fish must wear itself out as this nervous system fatigues and it is thus unable to keep up the intermittent discharge for more than a few minutes. This time is however, long enough to enable it to stun or kill small fish in its neighbourhood, which it is then able to eat at its leisure, which, being a sluggish fish, is a matter of considerable importance. It is also sufficient to provide a very formidable weapon for defence from the attack of any enemies who might otherwise prey upon it. One of the most remarkable of the whole series of phenomena connected with these fish, is the comparative immunity which they enjoy from the destructive influence of strong electrical shocks. When it is borne in mind that a very considerable portion of the current during the discharge of the organs traverses the brain and spinal cord of the very fish which produces the current, it will be realised to what extent the nervous system must be modified, in order to allow this to take place without any apparent physiological effect whether being produced.

(2) *Gymnotus.* The Electric Eel is a more formidable fish than the Torpedo, since it possesses four very large organs which run almost the entire length of its body, and which in adult specimens may measure 6 to 8 feet. The columns are situated so as to be parallel with the long axis of the body, and as in the Torpedo they are composed of a series of superimposed transverse plates. The Gymnotus thus resembles the Torpedo in the essential structure of its organ, but differs in having very much longer columns and consequently many more plates. The nerves are derived from nerve cells in the spinal cord and the fish is able to produce an intermittent electrical discharge of extraordinary force. It is thus capable not merely of killing other fish in its neighbourhood, but much larger animals, and Humboldt describes how the Indians dare

not cross the South American streams which are infested by these creatures, and therefore adopt the expedient of driving in their horses upon which the eels fasten and exhaust themselves in a vain effort to kill them. When exhausted, they are unable through failure of the central nerve power, to discharge the organ, and the Indians then cross in safety.

The immunity of the Eel from the effects of electrical currents is still more remarkable than that of the Torpedo. In each Gymnotus when it discharges its powerful organs, the electrical current must pass through its own brain, and hence it is not surprising that this fish is very insensitive to electrical currents—it feels neither its own discharge nor that of any of its neighbours.

(3) The most remarkable of all the electrical fish, is the *Malapterurus*, which is a comparatively small fish, 6 to 12 inches long. The electric organ is not situated in a mass of muscles as in the Torpedo and Gymnotus, but is in the skin of the animal. This skin is thickened and forms a thick mantle around the body of the fish, in which the same essential disposition of rows of plates can be observed. There are, however, an extraordinary number of plates, over 4 millions having been estimated to be present in one fish. Another remarkable fact, is, that the enormous nerve supply of all these plates, is derived from two single nerve fibres, which emerge each from a single nerve cell situated in the upper part of the spinal cord; each of these then has to supply countless branches to the 2 million plates in half the mantle.

The electrical shock and discharge of the Malapterurus is extremely intense.

(4) In the common skate there is a feeble electrical organ which forms a long tapering body situated one on each side of the tail; it consists of a few columns contain-

ing in some species *(Raia batis* and *Raia maculata)* a comparatively small number of highly differentiated transverse plates arranged in series. The electrical effects produced by the discharge of this organ are incapable, as far as we know, of producing any obvious physiological effects upon other living fish in the neighbourhood of the skate.

In conclusion the lecturer brought before the notice of the audience the following considerations bearing upon the question as to the extent to which the apparently anomalous functions of an electric organ are merely an exaggeration of activities common to all other animals. These may be grouped as follows :—

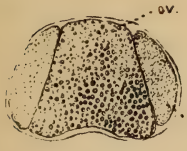
A. From embryological evidence each plate of the columns of the Torpedo and the Skate organs appears to be partly homologous with a striated muscle fibre and partly with the ending in the fibre of a motor nerve, the former portion is however reduced to very small amount whilst the latter part is very much increased in complexity.

B. The plate of every electrical organ is so constructed when fully formed that the nervous supply is limited to one side of the disc. On this side is a rich plexus of entering nerve fibres which divide dichotomously into a large number of finer nerve fibrils; these penetrate the deeper substance of the plates and appear to end blindly in it.

C. In all electrical organs the character of the electrical change which accompanies its functional activity is such that the innervated surface of each plate becomes galvanometrically negative to the other surface, in other words the electrical current which is produced and forms the shock, passes through the plate from the side the nerve enters to the deeper substance and out by the side free from nerves.

D. Physiological experiments have shown that a small but distinct electrical change of exceedingly short duration is invariably produced in every nerve of a living tissue when a nervous impulse traverses the nerve; such an electrical effect is present when a nervous impulse reaches the motorial nerve ending in the muscle, and its presence is the physical signal of the establishment there of the unknown processes which are associated with such impulses. Its character is such that the nerve fibres always become galvanometrically negative to the nerve ends.

E. The arrival of a nervous impulse at a plate must therefore produce an electrical change due to the fact that the nerve fibres entering the surface will become galvanometrically negative to the more deeply situated ends and hence in each plate an effect must be produced of the kind indicated in C. The enormous number of nerve twigs in each plate, the enormous number of plates, their arrangement in pile, and finally the structural device through which the impulses reach all the plates at the same instant of time, are the factors by which the comparatively insignificant change in an ordinary nerve has become magnified into the formidable shock of such an animal as the Gymnotus.



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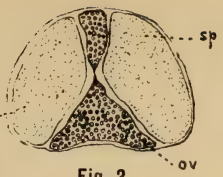

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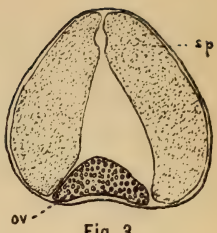

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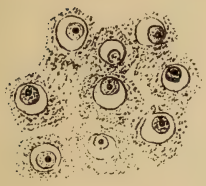
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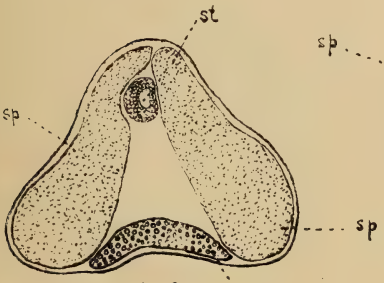

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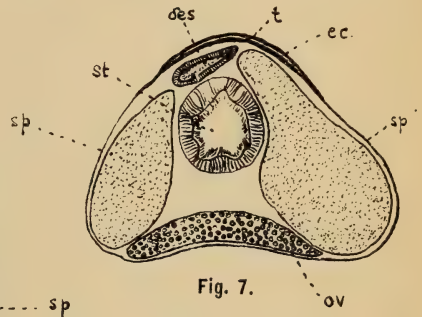

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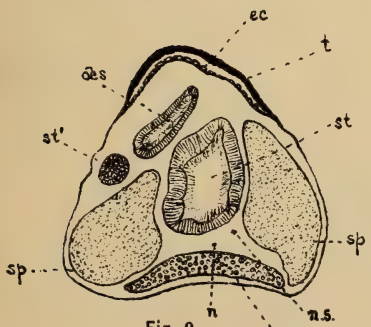

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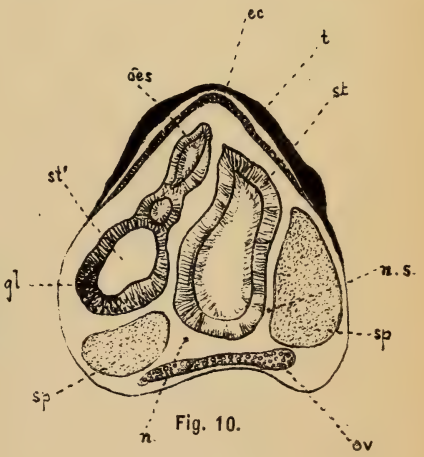

Fig. 10.

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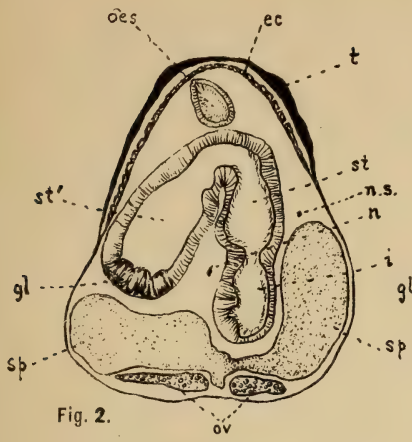

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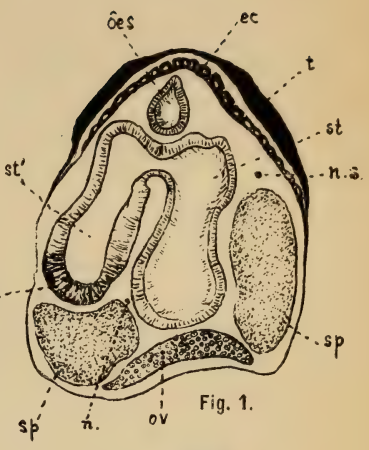

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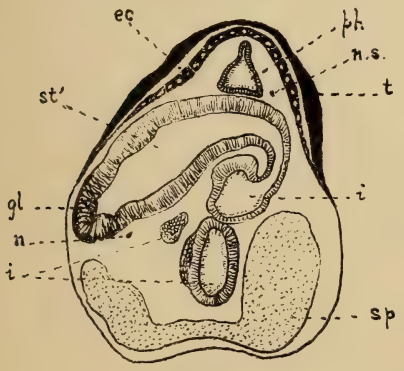

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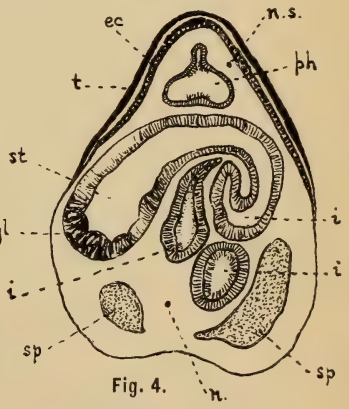

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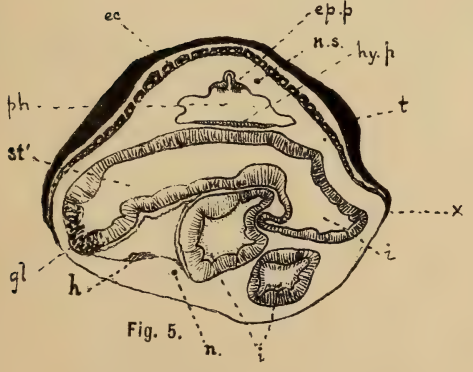

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Fig. 7.

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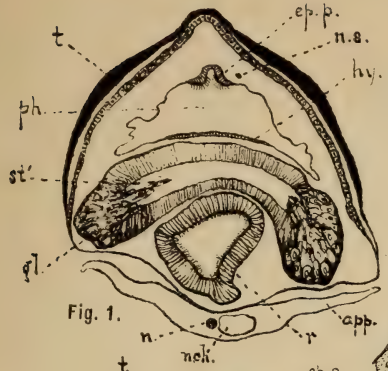

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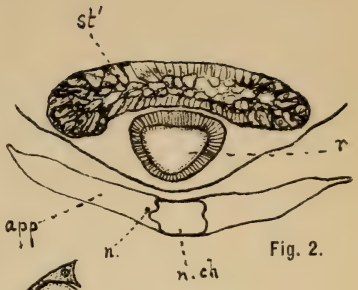

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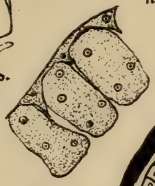
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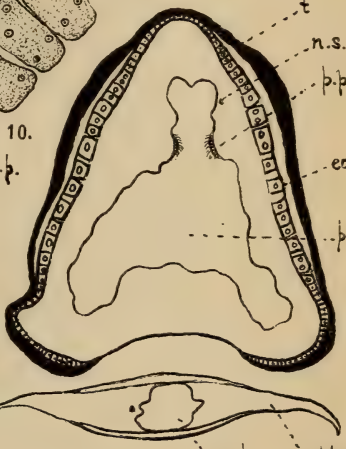

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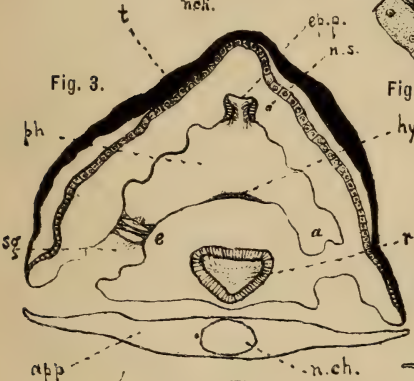

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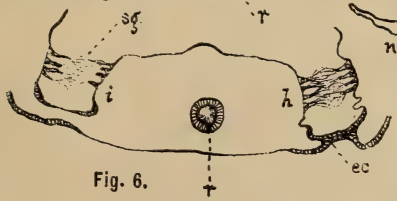

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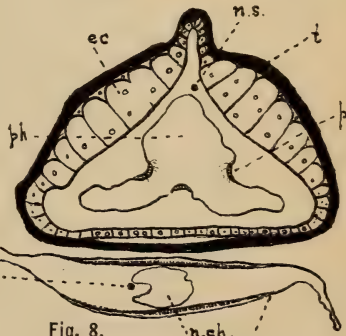

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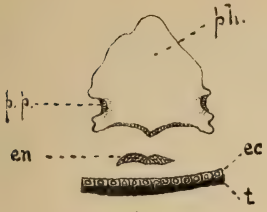

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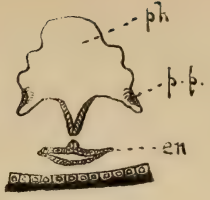

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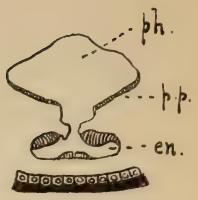

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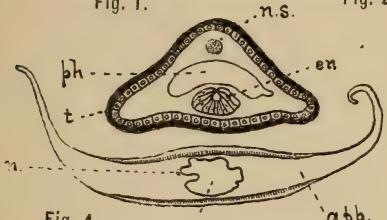

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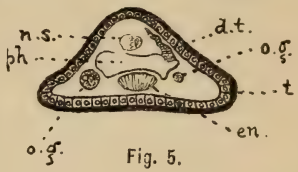

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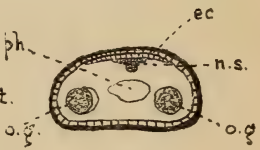

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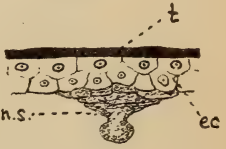

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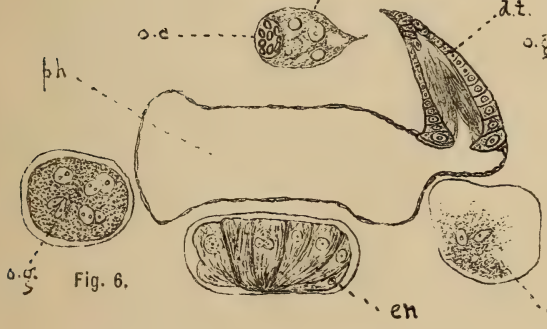

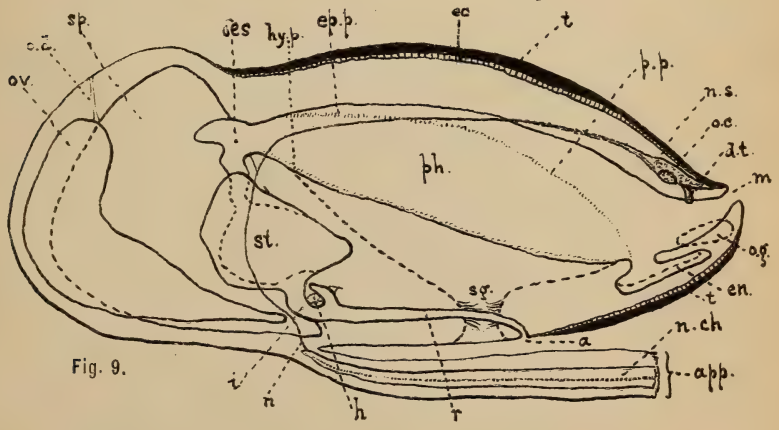

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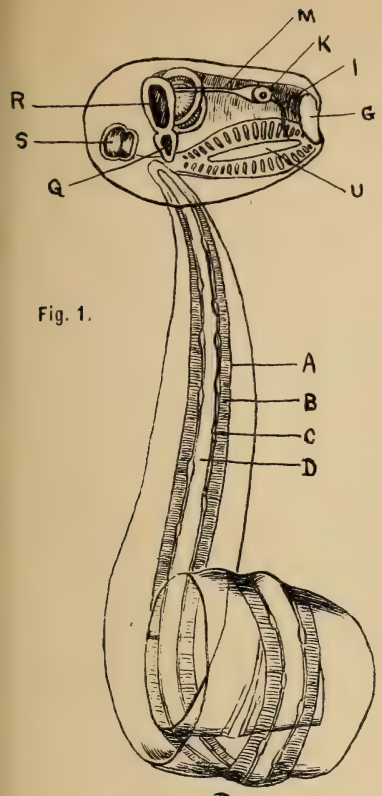

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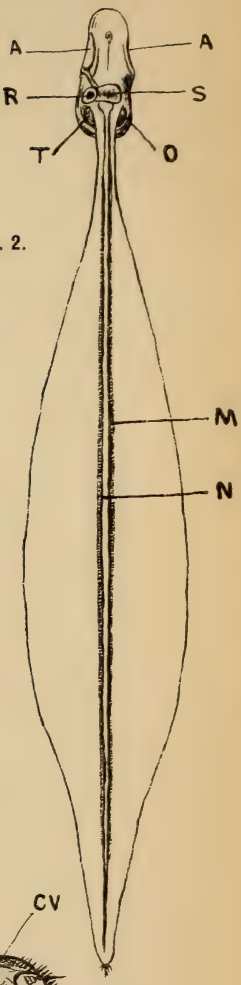

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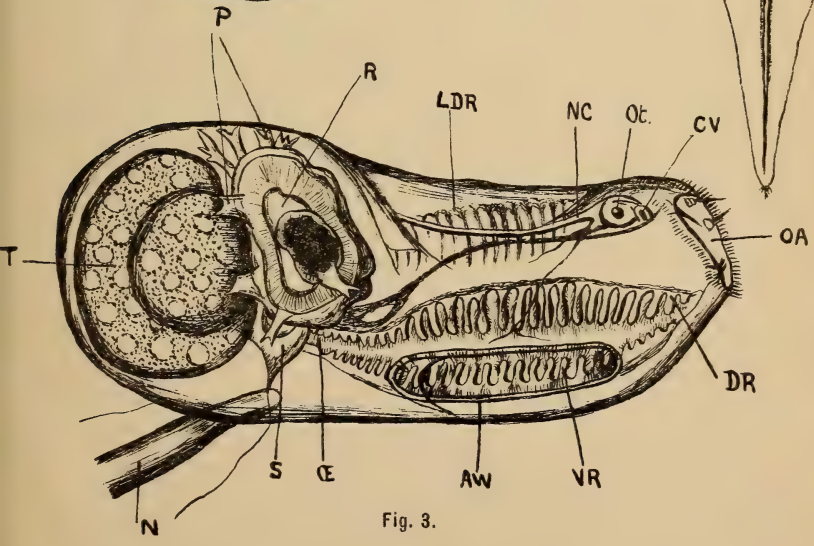

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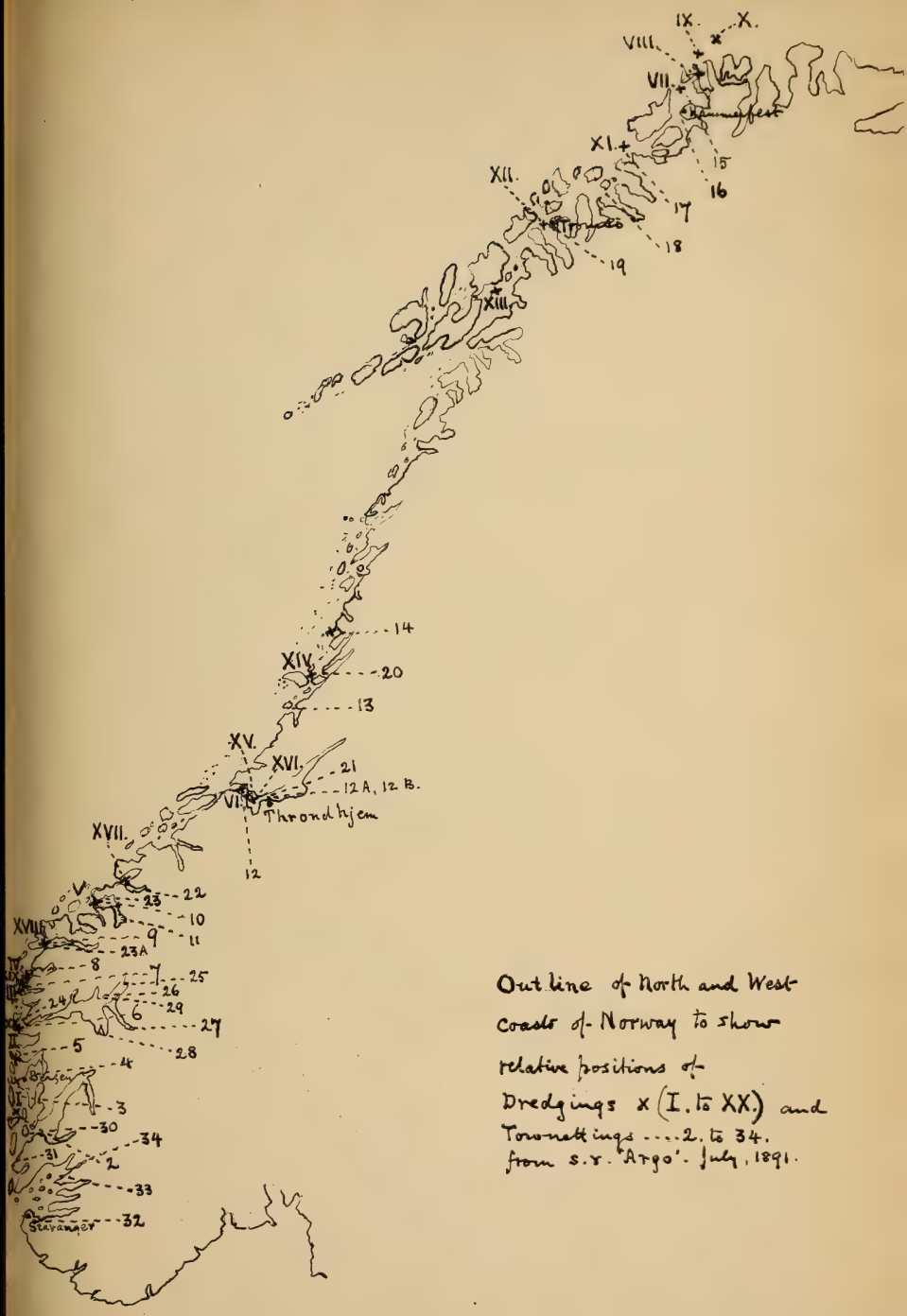
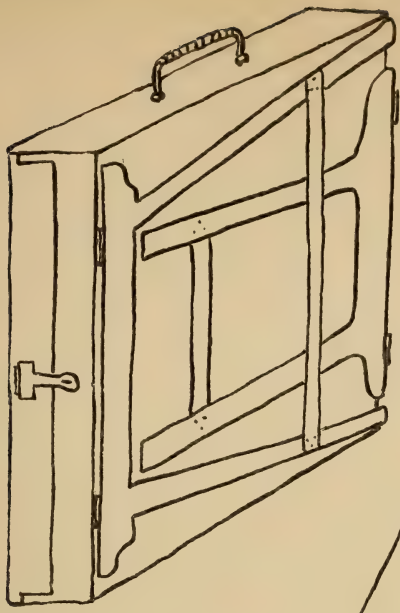


Outline of North and West Coasts of Norway to show relative positions of Dredgings × (I. to XX.) and Townettings ....2. to 34. from s.s. 'Argo'. July, 1891.



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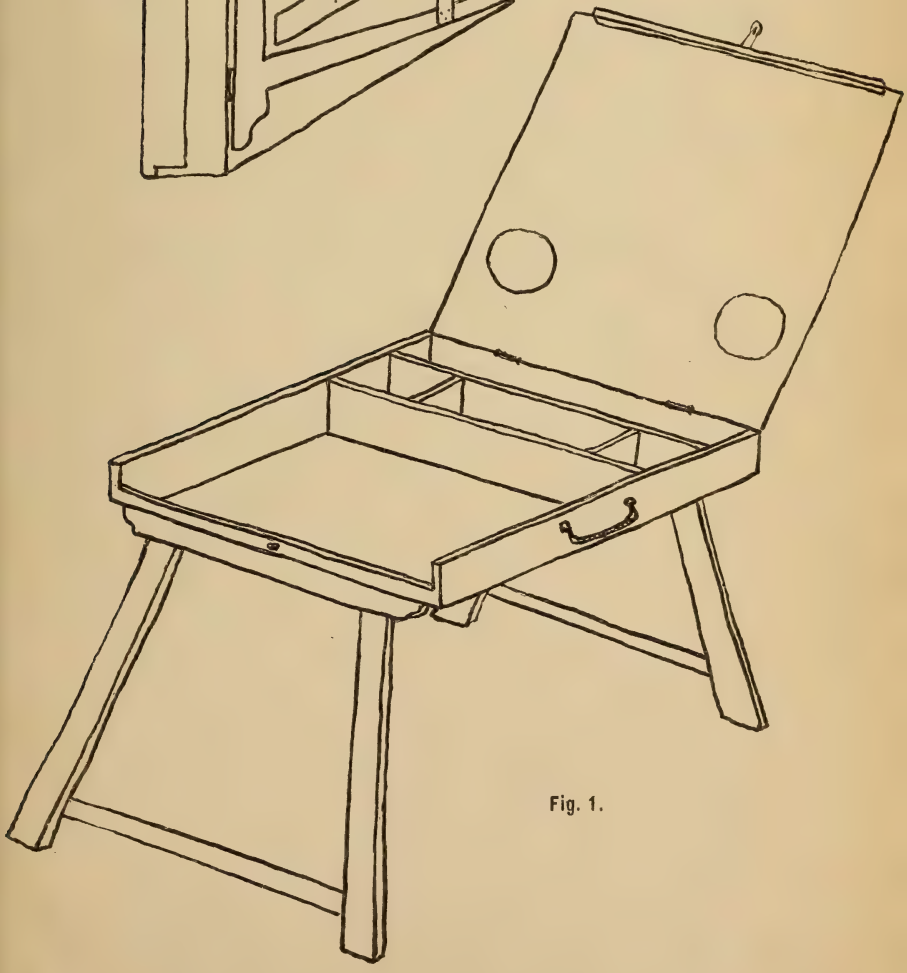

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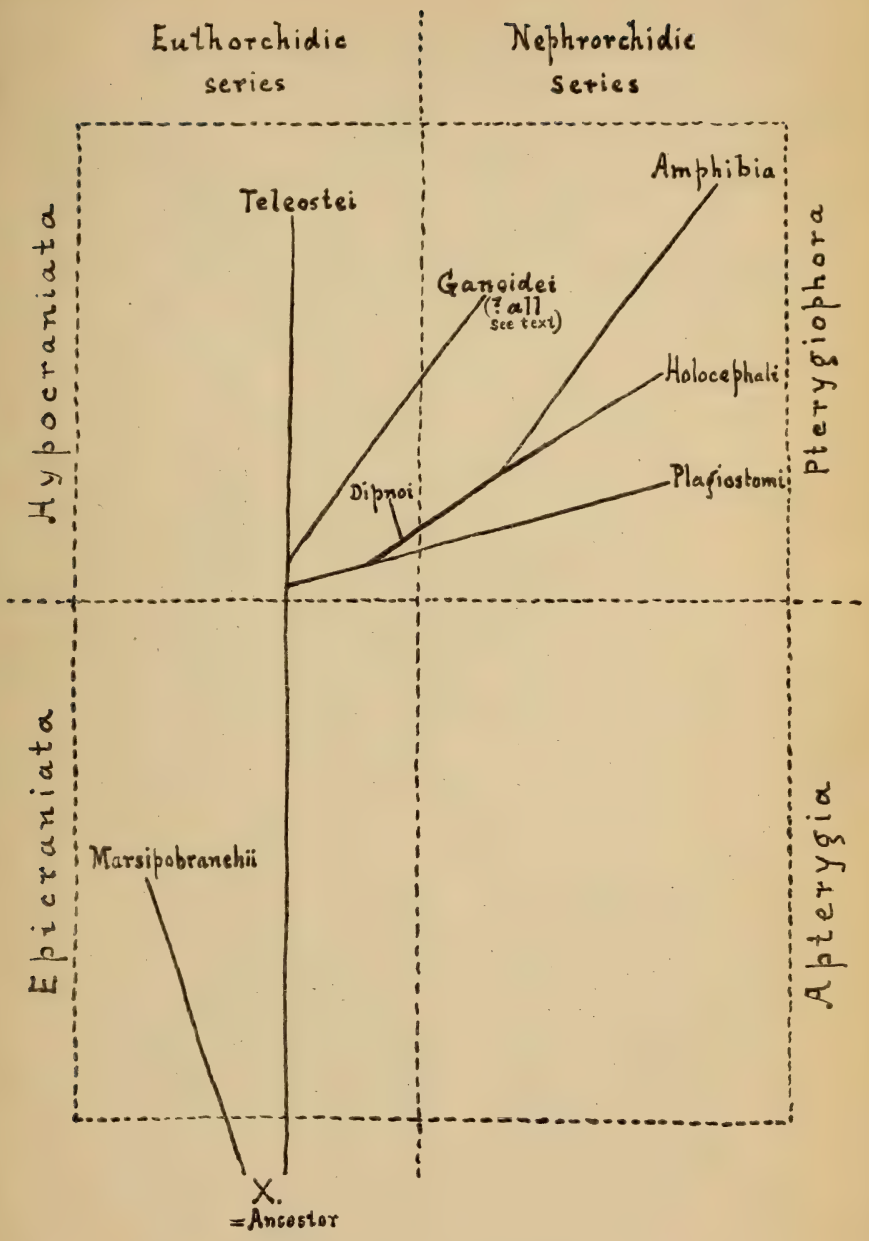
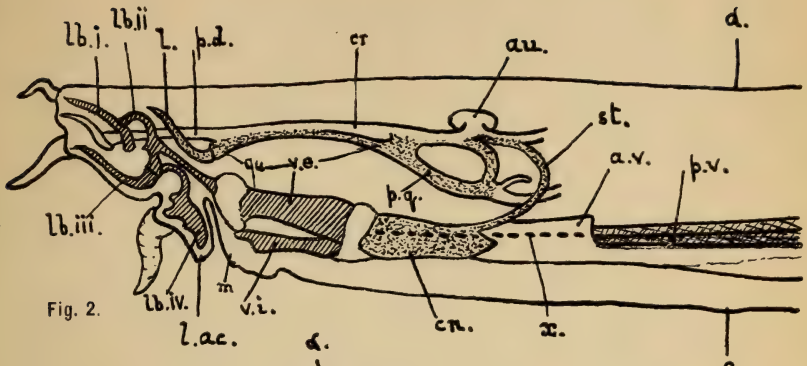


TABLE, indicating certain structural relationships of the living ICHTHYOPSIDA.



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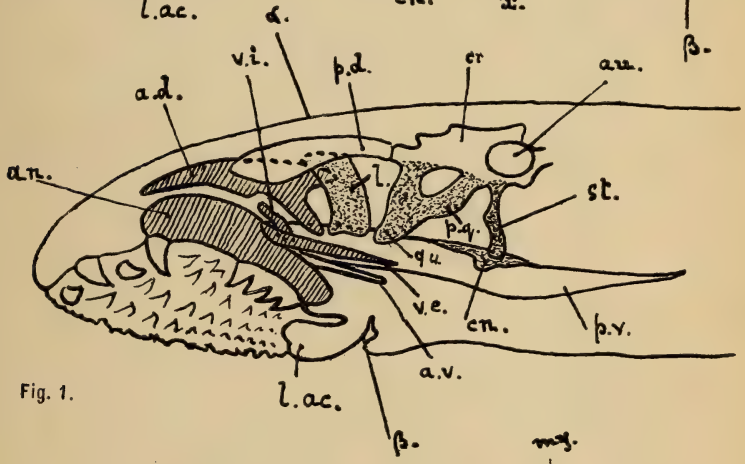

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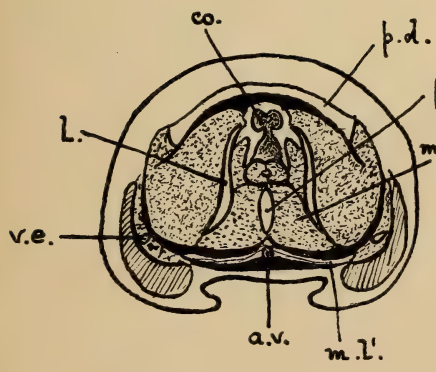

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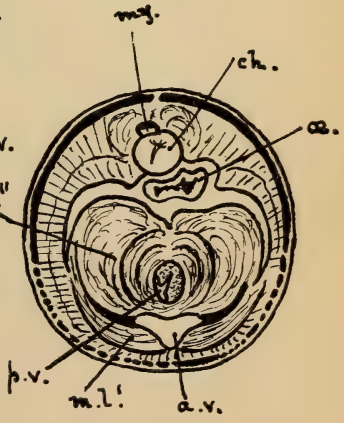

Fig. 4.

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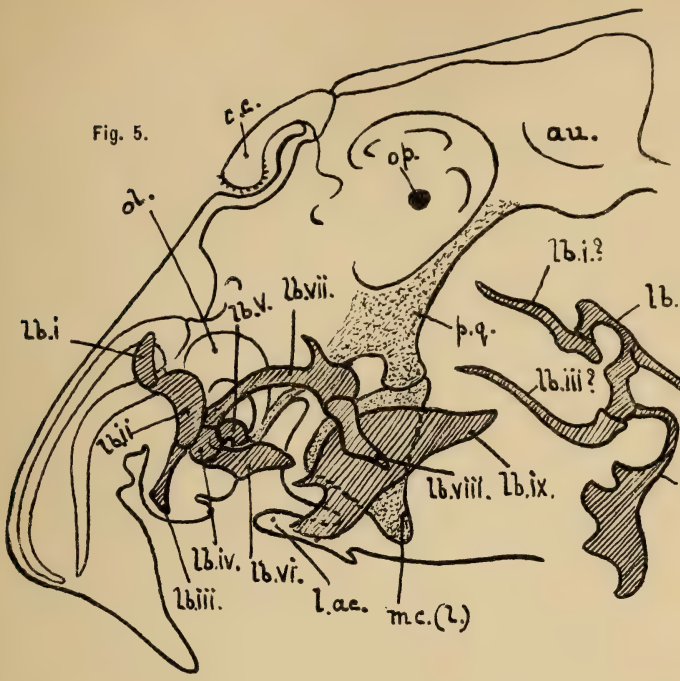
HEAD SKELETON OF MARSIPOBRANCHS.

Fig. 5.



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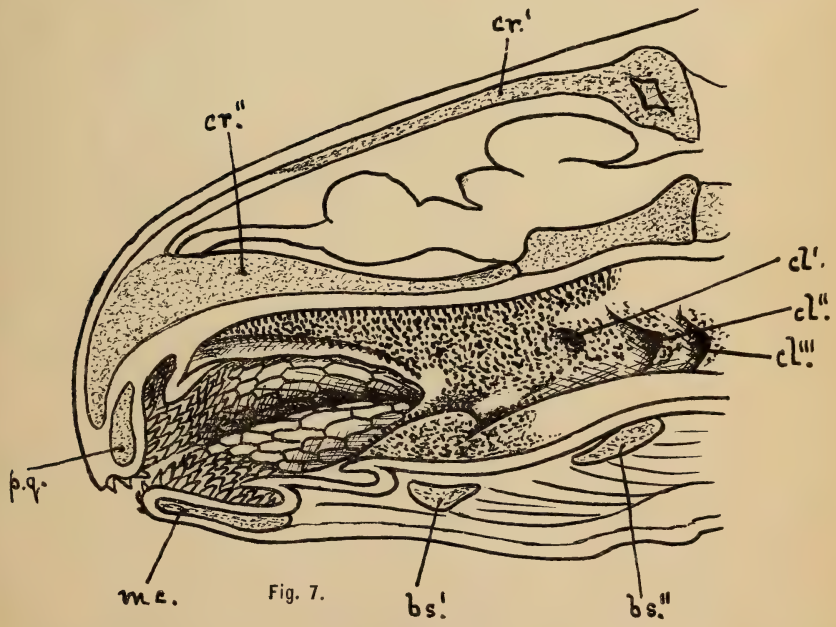

Fig. 7.

G.B.H. fecit.

HEAD SKELETON OF CALLORHYNCHUS
and BUCCAL SCUTES OF CESTRACION.